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ORGANISATION OF TRAINING PROGRAMME FOR LABORATORY ASSISTANTS

DEPARTMENT OF EDUCATION IN SCIENCE AND MATHEMATICS
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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STATE INSTITUTE OF EDUCATION
West Bengal

STATE INSTITUTE OF EDUCATION

Organisation of Training Programme

For

Laboratory Assistants

(A Suggested Model)

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Department of Education in Science and Mathematics
National Council of Educational Research and Training
New Delhi
1977

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Preface

In the course of last ten years, Science Education Programme has considerably expanded. A majority of the States have completed the pilot phase and are currently in either wider introduction phase or in the universalisation phase.

One of the important aspects of the UNICEF-assisted science education programme is to supply equipment to the Teacher Training Schools, with a view to making them self-contained for an improved training programme in preparing Science Teachers.

In the pilot phase 79 key institutions and 579 key institutions in the wider introduction phase in various States have been selected for supply of imported laboratory equipment, workshop tools and library books.

In addition, the programme also envisages the training of Laboratory Assistants from Teacher Training Schools. The training programme, has been designed by Dr. B. D. Atreya and Dr. O. L. Orekhov in the Department of Education in Science and Mathematics, NCERT to meet the needs of Laboratory Assistants employed in the Teacher Training Schools. During this orientation programme emphasis should be given to provide practical guidance to the trainees and give them the information they will actually need while they are at work. This programme was tried out in the training of Laboratory Assistants of Teacher Training Schools in the State Institute of Science Education, Jabalpur, Madhya Pradesh and at the Science Branch of the Directorate of Education, Delhi.

I would like to record my thanks:

(a) to Prof. B. Ganguly (NCERT), Dr. S. G. Gangoli (Reader, NCERT), Dr. D. Lahiry (Reader, NCERT), Mr. W. P. Kurchania, Director, State Institute of Science Education, Jabalpur, and Dr. N. N. Siddiqi, Field Adviser, Science Branch, UNICEF Cell, Directorate of Education, Delhi for their valuable suggestions for the improvement of this manual.

(b) to the staff of the State Institute of Science Education, Jabalpur and Science Branch, Directorate of Education, Delhi.

(c) to the UNICEF for the financial assistance in these training programmes and in getting this manual printed.

(d) to the State Institute of Science Education, Jabalpur, Madhya Pradesh, and the Science Branch of the Directorate of Education, Delhi for providing experimental base, facilities and equipment.

Any comments and suggestions for improvement of the suggested model are welcome, and may be addressed to the Department of Education in Science and Mathematics, NCERT, New Delhi.

A. N. Bose
Head of the Department of Education in Science and Mathematics, NCERT

New Delhi
1977

Explanatory Note

This manual contains four sections. The first section of the manual contains suggested model of the training of laboratory assistants during a period of 10-15 days alongwith the break-down of instructional work and syllabus for the training course. The second section covers the basic techniques of the science laboratory practice. Its purpose is to equip the laboratory assistants with the knowledge necessary for carrying out simple and common laboratory operations. This section also includes a description of some selected items of the equipment as there is no need for each and every item supplied under SEP to be described. As an aid to the trainees there are special sub-sections containing rules and instructions on how to perform the more complicated operations. Each chapter contains exercises meant for laboratory assignments. Emphasis is given throughout the section on the importance of observing safety rules, a knowledge of which is indispensable for successful work in a science laboratory. Since this is an instructional material for laboratory assistants, an attempt has been made to present the material in a form that can be easily grasped by the trainees.

The third section contains the list of practicals in science from the syllabi of the teacher training schools of different States.

The last section gives list of reagents, stains, enzymes and indicators commonly used in science laboratory. A list of equipment supplied by UNICEF is given in this section. Books for further reading have also been suggested.

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SECTION A

Model for the Training of Laboratory Assistants of Teacher Training Schools

An Introduction

The training programme for Laboratory Assistants has been designed to meet the needs of laboratory assistants employed in the teacher training schools.

The aim is to provide thorough grounding in fundamental laboratory practice and procedures and some knowledge of the underlying scientific principles. In addition to the laboratory practice, theoretical sessions are included in order to develop in the laboratory assistant trainees an ability to receive, interpret and transmit scientific information. This ensures that trainees have sufficient opportunities during the practical sessions to practice and develop their skill in carrying out techniques and procedures often needed for work in a science laboratory/room.

The main objectives of the training programme are :

a) to give comprehensive information about equipment supplied by UNICEF with reference to the current TTS's syllabus,

b) to give information about the basic operations performed in science laboratory/room and the equipment used for these purposes,

c) to develop a competency in demonstration using NCERT science kits,

d) to give information about the safety measures in science laboratory/room,

e) to encourage independent thinking for improvisation and use of locally available materials.

Programme and Organisation

The organisation and duration of the course will vary from 10 to 15 days in the States according to local requirement and background of the trainees. The training programme has been designed with these two ends in view : (i) to give progressive experience and practice in the basic processes, and (ii) to present activities which will appear in themselves, worthwhile and interesting to the trainees. Conditions vary so much from place to place that only the resource person can decide what he shall include in the course at any given time. It is proposed that each day there will be three sessions of two hours durations each. In the first session, the resource person should deliver a lecture on using different methods of science teaching. The lecture should be followed by a discussion on the difficulties of the participants. For the practical work (second and the third session), the whole group should be divided into sub-groups. Each group should have five to seven participants, one resource person should be associated with each group. Different types of activities should be visualised for such a course, e.g.,

a) demonstration activities during lecture-discussion sessions,

b) experimental work based on any aspect of the lecture content for updating participants' knowledge,

c) workshop practice for developing skills in improvisation,

d) field trips,

e) familiarisation with kits, UNICEF equipment, and organisation in group work,

While using UNICEF equipment, science kits, participants should perform the experiments related to the content of the topic which was introduced. One of the members from each sub-group should have an opportunity to present and demonstrate experiments, which they had earlier performed. This is to ensure that the participants develop skills in handling the UNICEF equipment and the kit's items. Each resource person will have his own particular way of teaching, but once a point has been demonstrated, the trainee must practice for himself if he is to truly learn. Moreover, the value of his learning will become more apparent to him if it results in a pleasing experience.

Quite a number of sessions will be planned for the practical work. The laboratory trainees will be expected to show initiative, versatility and skills of improvisation in their execution of projects. The work will be based upon a series of projects appropriate to the work of a science laboratory assistant. Suitable projects, such as the construction of demonstration models would develop the scientific skill. A breakdown of the instructional work of the training course has been proposed. Tentative syllabus for training is also given for consideration of the organisers in the States.

Criteria for Selection of Trainees

The selection of trainees for the course is within the discretion of the State Institute of Science Education, but the DESM recommends that in view of the greater emphasis on workshop practice, the number of participants in a training course should be between 30 to 35. Furthermore, each group for a training course should be, as far as possible, homogenous in respect of academic background.

Breakdown of Instructional Work of the Training Course

		Sessions
I. Introductory.		
a) Objectives of the course. b) Information about SEP.		1
c) Information about the new system of education : 10+2+3 pattern.		
II. Identification and use of UNICEF equipment and tools.		2
III. Demonstration and working with primary and middle-stage kits (Physics, Chemistry, Biology).	Demonstration	3
	Actual handling	6

IV.	Improvisation and workshop practice including preliminary information about materials and tools (demonstration and practice).	6
V.	Science laboratory and equipment.	5
VI.	Laboratory management.	3
VII.	General laboratory procedure.	1
VIII.	Physical laboratory techniques.	3
IX.	Chemistry laboratory techniques.	3
X.	Biological laboratory techniques.	3
XI.	General safety and first-aid in the science laboratory.	2
XII.	Audio-visual aids.	2
XIII.	Evaluation of the training course and refinement of the model.	1
XIV.	Organisation of field-trip.	3
XV.	Concluding session.	1
		45

Syllabus of the Training Course

1. General Laboratory Procedure

a) Standard laboratory fittings and services; their correct use and care.

b) Storage, handling, dispensing, use and disposal of chemicals, solvents, solutions, liquified gases, dangerous chemicals, poisons. Regulations governing purchase and use of alcohol and inflammable solvents. Sampling and grinding. Treatment of spillage.

c) Care, cleaning, handling. assembly and use of laboratory apparatus and containers of all kinds, including stirrers, shakers, constant level and constant feed devices, heating apparatus and thermostats, compressed gas cylinders and reducing valves.

d) Use of fume cupboards, safety screens and protection for eyes, hands and body.

2. Laboratory Management

a) Laboratory documentation. Purchase and receipt of goods. Simple accounting procedures. Laboratory records. Inventories and stock control. Indexing of catalogues and technical literature.

b) Storage and preservation of apparatus, chemicals, biological materials and specimens. The preparation of standard solutions and reagents.

c) Sources of information: use of reference books, textbooks, catalogues, periodicals and relevant TTS syllabus.

d) Knowledge relating to the purchase, storage and disposal of alcohol, inflammable solvents, poisons and dangerous chemicals.

e) The organisation of adequate first-aid facilities.

3. General Safety

- a) Identification and location of master switches and master gas cocks.
- b) Hazards involved in the use of the main gas and electricity supplies.
- c) Precautions against fire and explosion, action in an emergency involving fire or explosion, correct use of fire extinguishers.
- d) Correct use of electric plugs, fuses, flexible leads.
- e) First-aid treatment of persons suffering from burns, electric shock, gas poisoning.

4. Safety and First-Aid in the Science Laboratory

- a) Precautions when using electrical circuits.
- b) Precautions when using/preparing (i) acids, alkalis, and other corrossive substances (ii) toxic substances, (iii) substances which react with water (iv) inflammable solvents and gases (v) mercury.
- c) Precautions when (a) handling glassware and assembling apparatus, (b) fitting glass tube and rods into corks, (c) removing corks, and glass stoppers from vessels, (d) handling and carrying large containers, and transferring chemicals from them (e) using compressed gas cylinders.
- d) Precautions when using dissecting instruments, razors, syringes, hypodermic needles, sterilizers, fixatives and other toxic reagents.
- e) The danger of infection in handling live cultures of micro-organism.
- f) Correct methods of disposal of pathogenic materials, antiseptics.
- g) Correct handling of laboratory animals; dangers of bites and scratches.

5. Laboratory/Workshop Practice

- a) The use of simple handtools.
- b) Introduction to functions and simple operation of bench drills, lathes and grinders.
- c) Simple glass blowing using different kinds of glass, cutting, drawing, sealing and making simple joints.

6. Science Laboratory and Equipment

- a) General principles concerning facilities for science instruction in schools.
- b) Multipurpose science room. Advantages of multipurpose science room.
- c) The design requirements and general features :
  - i) floors
  - ii) walls and ceilings
  - iii) illumination
  - iv) heating and ventilation
  - v) plumbing
  - vi) electricity
  - vii) fume cup-board
  - viii) potential expansion
  - ix) furniture
  - x) storage of apparatus and supplies

- xi) storage of charts, maps, filmstrips and films
- xii) facilities for the science library
- xiii) wall display
- xiv) teacher's room

7. Primary and Middle-Stage Kits

- a) Physics (Parts I, II and III)
  - i) items of equipment
  - ii) suggested demonstration of experiments
- b) Biology
  - i) items of equipment
  - ii) suggested demonstration of experiments
- c) Chemistry
  - i) items of equipment
  - ii) suggested demonstration of experiments
  - iii) list of chemicals
  - iv) safety precautions
- d) Primary kit
  - i) items of equipment
  - ii) suggested activities
- e) Repairing of kits equipment, replacement of items in the kits and of chemicals.

8. Identification and Use of UNICEF-Supplied Equipment Related to the Area of Physics, Chemistry and Biology

9. Laboratory Techniques

- a) Physics, laboratory techniques :
  - i) Mechanics
  - ii) Heat
  - iii) Sound
  - iv) Magnetism, electricity, etc.
    (Techniques relating to electricity are given below as an illustration)
  - v) Electricity
    - i) Electrical instruments, operation, repair and standardisation of common types of meter, single and multi-range, moving coil, galvanometers
    - ii) electrical laboratory equipment, applications and repair of resistors
    - iii) testing equipment, use of D.C. potentiometer
    - iv) D.C. circuits, drawing, interpreting, assembly and fault finding.
    - v) Electricity supplies in the laboratory, A.C. and D.C. distribution, correct wiring, capacity of wiring, fuses. Maintenance of secondary cells.
- b) Chemistry Laboratory Techniques :
  - i) Preparative methods : preparation of some gases selected from the following : hydrogen, oxygen, carbon dioxide, ammonia, chlorine, hydrogen

chloride, hydrogen sulphide, sulphur dioxide, nitrogen, nitric oxide. A selection should be made on the basis of different methods for preparation, collection and reactivity. Preparation of solutions of acids and hydroxides.

ii) Separation and partition of solutions: decantation, filtration, centrifugation, evaporation, sublimation, crystallisation and recrystallisation. Purification of water by distillation. Causes of hardness of water and its removal.

iii) Preparation of solutions of acids and hydroxides. Normalities and molarities.

c) Biology Laboratory Techniques :

  i) Preparation and use of isotonic solutions, perfusion fluids, simple fixatives, preservatives, buffer solutions, detergents, antiseptics and disinfectants.

  ii) The selection, care and use of dissecting instruments. Methods of humane killing. An outline of the law relating to the use of laboratory animals. Preparation and handling of dead and preserved materials.

  iii) Simple methods for the counting of cells; the measurement of growth by determining the increase in length, area and total weight.

  iv) The care and use of dissecting lenses and microscopes.

10. Materials and Improvisation in Science

a) Selection of materials :

  i) Comparison of factors involved in the selection of materials, availability, cost, physical, chemical, electrical, thermal and mechanical properties, ease of forming, durability under working conditions, including resistance to corrosion, safety factors.

  ii) Main types of materials available; metals and alloys, plastics and rubbers, ceramics and glasses, wood, composites.

b) List of materials that are useful for the activities.

c) List of materials that are easily available.

d) List of chemicals that are available in the ordinary shops or medicine stores.

e) Advantages of improvised apparatus :

  i) Economical
  ii) Scientific approach
  iii) More facilities
  iv) Learning by doing
  v) Psychological value
  (vi) Educational value

f) Improvised apparatus.

11. Audio-visual Aids

a) Optical projectors: (list of items) filmstrip and slide projector, 16 mm sound projector. Proper use and maintenance, care of films, types of screen.

b) Preparation of charts, graphs, histograms and diagrams for illustration and display.

d) Construction of the Models:

  i) Static models : Model constructed in coloured cardboard or wood.

  ii) "Working" model or modified model.

Planning Aspects of the Organisation of the Training Programme

Planning of the programme has two aspects, viz., academic and organisational.

Academic Aspect

a) It is suggested that the representatives of the following institutes should be associated in the initial stages :

  i) State Institute of Science Education.

  ii) State Institute of Education.

  iii) State Directorate of Education.

  iv) NCERT/Regional College of Education :

  Two or three teachers' training schools should be the beneficiaries of this programme.

b) An analysis of the problems and needs of the State in respect of teacher education should be first done in order to develop criteria and accordingly the objectives, and the content of the course should be drawn up as also the programme of activities which would be necessary to achieve the objectives, through a suitable treatment of the content.

Organisational Aspect

a) States may consider a number of institutions in selecting the venue of the course. It may be any one of these : State Institute of Science Education, State Institute of Education, Regional College of Education (if there is one in the State), or even a good Primary Teacher Training School. All UNICEF supplies—the equipment, the library books, the kits should be made available for the period of the training course because one of the aims is to show how these supplies can be used for teacher training.

b) List of apparatus, chemicals, films, filmstrips, kits, textbooks, teacher's guides required for the performance of activities in groups, showing total quantity/number of items required should be very carefully drawn up. Steps for procurement should be taken so that all these materials should be made available at least a few days before its commencement.

Supply of Literature

The cyclostyled material should be made available to participants before the start of the course. During the course, the participants should be supplied with detailed synopsis of all lectures, and important findings of the group work. Whatever transpires during the course and is likely to be useful to them in their work at the institute should be made available to them during the course. It is suggested that some channel of communication for follow-up work after the course should also be established.

Informations and Suggestions to the Participants in Advance

i) Each participant should be supplied with a working paper containing the objectives of the programme, strategy of work, the syllabus to be covered during the two weeks, break-up of the programme and the schedule of the work. It is suggested that these materials be regarded as tentative and liable for revision after discussions with the participants.

ii) Each participant should be requested to prepare a list of the difficulties in using UNICEF equipment, science kits, which could be discussed during the course.

SECTION B

Basic Techniques of Science Laboratory Practice

CHAPTER 1

Introduction to Laboratory Work

1.1 Why is Knowledge of Laboratory Techniques Necessary ?

For working in a science laboratory, it is essential not only to learn to understand the assignment but also to know how to carry it out. The laboratory assistant, in addition to theoretical knowledge must be trained in carrying out laboratory techniques. He should acquire skill in working with glassware and various apparatus and learn to apply the correct methods and procedures in performing laboratory experiments.

Though the type of experiments may vary from laboratory of TTS of one State to another, the basic techniques are the same for all laboratory work.

Methods and procedures that permit the minimum expenditure of materials should be chosen for carrying out an experiment.

1.2 What is Required for a Laboratory Assistant ?

It is necessary to have a laboratory assistant in every laboratory of a Teacher Training School. It is not possible to carry out laboratory work efficiently and effectively without the help of a laboratory assistant. It is the laboratory assistant who has to look after the cleanliness, organisation and upkeep of the laboratory. The teacher cannot do all these things in addition to his teaching duties. He can only supervise the work of the laboratory assistant.

It is necessary that everything in the laboratory should be properly arranged and different apparatus and chemicals have got to be prepared for demonstration and practical work.

Work in a science laboratory is characterised by certain specific features which in turn make certain demands on the laboratory assistant. First of all, he should have a background of science at least upto High School/Higher Secondary School. He must be accurate. He must perform all experiments, reactions, and related operations accurately, in strict accordance with the instructions of the method-master, or those laid down in textbooks and manuals. Particular care should be taken in working with glassware, various apparatus and instruments, equipment and the balance.

The laboratory assistant must be conscientious. All work in science laboratory must be carried out scrupulously, with a due sense of responsibility for the results obtained. If anything is not clear, it is necessary to consult the method-master.

The laboratory assistant must be attentive when performing reactions, and should use only those reagents as are specified in the manual. He should be especially attentive when working with apparatus, electrical equipment, and so on.

He must be observant and should learn to notice seemingly insignificant details on which the success of an experiment largely depends.

He must be economical, and should not use more materials, reagents, or glassware than is necessary. He must not be wasteful when using distilled water, electric current, or gas.

Finally, he must learn to rationally and correctly utilise the time alloted for a given task. Each minute should be used to full advantage to complete the given assignment in time.

1.3 Duties of Laboratory Assistant

1. To assist the method-master in setting up of science room/laboratory.
2. To arrange and manage all the apparatus and other things of the laboratory.
3. To repair or replace the broken apparatus.
4. To arrange before hand all the things required in experiment to be demonstrated in the science-room.
5. To help and provide all the necessary requirements to the students while they make experiments.
6. To put labels on reagent bottles having different chemicals and to arrange them properly.
7. To help the students in their activities.
8. To clean the pots of glass and to keep them on high places.
9. To clean the tables and the apparatus.
10. To collect and arrange certain requirements of laboratory which are available only in a particular season.
11. To keep the science method-master informed about the students who cause harm to the laboratory.
12. To work in accordance with the directions of the science method-masters.
13. To assist the method-master in demonstration, in performing science activities at the laboratory, in making acid solutions and to help in organisation of science exhibitions, fairs, etc.
14. To assist the method-master in purchasing and testing the science materials and equipment for science room/laboratory.
15. To procure and return films/filmstrips from different agencies and to operate with film projectors and other audio-visual aids.

There must be a laboratory assistant for the proper and efficient working of a laboratory.

1.4 What a Science Laboratory Does and How it is Organised ?

Teacher Training Schools :

Teacher training schools referred to herein are those institutes that admit students who are secondary or higher secondary certificate holders and impart to them professional training to enable them to become qualified teachers for teaching primary/middle school classes.

Nowadays, almost all teacher training schools have science laboratories. A science laboratory usually consists of a separate room and is equipped for the purpose it serves. There should be a separate place for washing glassware, weighing of samples, etc. A laboratory should also have an apparatus for producing distilled water. A science laboratory is a complex organisation in teacher training schools.

1.5 Norms for Laboratory of Teacher Training Schools

1.50 *Science Room for the Teacher Training Schools* :

The minimum requirement of a laboratory for the training schools is a composite room which could be termed as a 'Science Room'.

'Science Room' is a place where :

a) There shall be seating arrangements to accommodate the teacher-trainees.
b) There shall be cupboard/shelves/racks to store all laboratory equipments needed for teaching science and imparting workshop practice to the trainees.
c) There shall be a "Nature Corner" or "Living Corner" of living animals and plants.
d) There shall be shelves accommodating preserved biological and earth-science materials, needed for teaching science to the trainees.
e) The method-master does all classroom science teaching.
f) The method-master conducts experimental demonstrations.
g) The trainees carry out all individual experiments and indoor project work in science.
h) The trainees prepare teaching aids in science and learn the techniques of operating audio-visual aids.

1.51 *Specifications of a Science Room :*

Any large room, preferably with a dimension 15m × 6.5m and with ventilators, windows and sufficient lighting would serve the purpose of a 'Science Room'.

A 'Science Room' has :—

a) A preparation-cum-store room.
b) A space in the class for the demonstration table (with cupboards)
c) A seating arrangement for 40 trainees.
d) Three to four sinks along the wall on one side and a sink attached to the demonstration table.
e) Four or five built-in shelves for display of models, specimens, etc.
f) Display boards on the back wall.

1.52 *Variations for the dimensions of Science Room :*

It is desirable to have an area of 25-30 sq. ft. per trainee for the calculation of which the entire area including the preparation-cum-store room and storing spaces may be taken into consideration.

1.6 The Laboratory Bench

The bench (or desk) is specially designed to meet the requirements of work in a science laboratory. It is higher than ordinary tables and usually has shelves, drawers, and cupboards for storing reagents, glassware and various equipment. To protect it from water and chemicals, the top surface of the bench is usually covered with plastic material or such other material. Sometimes it is specially treated.

The bench must be kept clean and in good order.

Care should be taken to prevent acids, corrosive solutions, and other aggressive chemicals from getting onto the table top. Under each bottle containing such a liquid, should be placed a piece of glass or plastic material resistant to the action of acids or alkalis. If such liquids are accidentally spilled, the affected area should be immediately cleaned up. When the nature of the spilled liquid permits, the affected area may be wiped up with a rag and washed with water. But if the spilled liquid is concentrated sulphuric, hydrochloric, or nitric acid, cloth should not be used. The affected area should first be covered with sand which is removed with a small wooden board, then washed with a soda solution and after a few minutes dried with a rag.

The laboratory bench should never be overcrowded with glassware and apparatus. On the table, there should only be what is necessary for carrying out a given experiment. The shelves both inside the bench and on top of it should be kept thoroughly clean. A moist rag may be used for wiping the shelves and the reagent bottles.

Glassware and apparatus should be stored in separate drawers. The bottom of each drawer should be covered with a clean sheet of paper. For storing thermometers, hydrometers, and other measuring instruments made of glass, one of the upper drawers should be used and the bottom of this drawer should be lined with cotton wool or other soft material. One drawer should be reserved for storing corks; it is best to keep them in separate boxes according to their size. Rubber stoppers should be similarly stored in separate boxes. In the same drawer may be stored small metal objects such as clamps and rings.

The cupboards are meant for storing glassware, reagents and apparatus, which are kept separately and in a definite order. Each bench should be equipped with water taps and drains. A sink with several water taps, one of which is equipped with a water-suction pump, is usually installed at one end of the table.

Near the sink, there should be a basket for drug waste, and also an earthenware jar for liquid waste, which for health, and safety reasons should not be poured into the sink. It is necessary to remember not to pour into the same jar liquids that can undergo chemical reaction with one another leading to the formation of poisonous substances. When possible, the laboratory bench should be equipped with gas taps. If electricity is used in science laboratory/room, plug sockets, should be installed on the bench.

Over each working place, there should be an electric lamp giving sufficient light for observing operations and experiments. Too strong light is harmful to the eyes. In some laboratories, it is desirable to have fluorescent lamps (daylight lamps). Such lamps are necessary for all types of work. At the end of each working day, before leaving the laboratory, clear the bench of everything that is unnecessary, wipe it with a rag, close all the gas and water taps, and turn off the current from electrical equipment and appliances.

Make sure that all the drawers, cupboards and windows are closed and motors turned off.

The laboratory assistant is responsible for the order and safety in the laboratory in which he works. Thus, one of his main duties is to keep everything in the laboratory in good order.

1.7 Preparation of Distilled Water

Water from the general water supply main contains various impurities. This can be readily confirmed by carefully heating a small amount of water in a watch glass until the water is completely evaporated. Left on the glass will be a white residue which consists of inorganic salts. Tap water, therefore, must not be used for preparing solutions for work that require accuracy. Water can be purified by distillation. No science laboratory can function without distilled water. It is needed for many purposes; preparing solutions, rinsing glassware after it has been washed, etc.

Distilled water is obtained by distillation of tap water. Distilled water usually contains traces of mineral impurities. It can also contain admixtures of gaseous inorganic and organic substances absorbed from the air, such as ammonia, carbon dioxide, etc.

To obtain distilled water, apparatus of various productive capacity are used. A still apparatus for preparing distilled water is shown in figure 1.1. It is heated with Bunsen burner or kerosene stove. It can produce about two litres of distilled water per hour.

A certain amount of distilled water is usually stored for future use. It is imperative, therefore, that the bottle for storing the water should be meticulously clean. For this purpose, it is preferable to use glass bottles that have been previously used for this purpose and whose inner walls have thus been sufficiently bleached out. To prevent bleaching, the inner walls of the vessels are often coated with paraffin. The cork or rubber stoppers used for closing the bottles should be submerged beforehand for 3-5 seconds in molten paraffin and then dried for several minutes. Ground-glass stoppers are excellent for closing the bottles. Small amounts of distilled water can be conveniently stored in polyethylene wash bottles. For everyday use, distilled water is kept in bottles set up as shown in fig. 1.2. The rubber tube is closed with a pinch clamp. To prevent carbon dioxide from

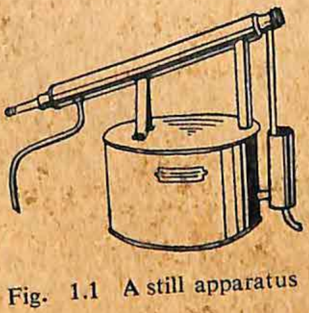

Fig. 1.1 A still apparatus

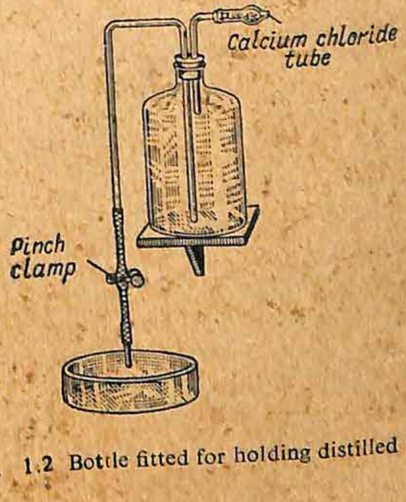

Fig. 1.2 Bottle fitted for holding distilled water

contaminating the distilled water, the calcium chloride (guard) tube is filled with soda lime. Bottles containing distilled water are placed on a shelf near the water sink. Care should be taken to prevent leakage of distilled water.

1.8 Rules and Organisation of Laboratory Work

The pupil-teachers should, from the start, train themselves in accuracy and pay attention to details.

The student's main place of work in the laboratory is his bench, which should be kept clean. Only in that way can accuracy be ensured. Dirt is often the reason for distorted results. Therefore, only clean glassware and apparatus should be used.

Laboratory work should be done without undue haste and without slopping and spilling reagents. If any solid reagent gets on the bench, it should never be put back into the bottle of the clean reagent, but should be brushed up and given to the laboratory assistant. and the bench (or contaminated article) should immediately be washed and dried. If large amounts of liquid, acid or alkali are spilled, the laboratory assistant should be informed at once and the spilled reagent should be quickly wiped up with cotton waste taking care not to burn the hands or damage the clothes. Concentrated alkali or acid should be handled with special care. If any of these gets on the skin, the latter should be washed immediately in running water, and first-aid obtained from the laboratory assistant.

In all cases of accident, inform immediately the laboratory assistant and consult a doctor. When an experiment is being performed, the bench should be free of anything extraneous to the work in hand. All objects required should be arranged in a definite order so that they are conveniently at hand and do not hamper manipulations. It will be found most convenient to have the test tube rack and set of reagent bottles in the middle of the bench, the laboratory manual and the notebook on the right, and the burner, ring, stand, baths, wash bottles, etc. on the left. A cloth towel, (or cotton waste), and asbestos mat should always be at hand.

Hot objects, especially very hot ones, should always be placed on an asbestos mat.

Apparatus must be handled with care. Expensive or dangerous reagents (especially solutions containing compounds of silver, mercury etc.) should never be poured down the sink, but should be put into special bottles provided for the purpose.

Special precautions must be taken and safety regulations observed in the laboratory. Never work with highly inflammable substances near a lighted burner. Poisonous or foul smelling substances should be handled only in the hood.

Experiments should be performed only with reagents of the required concentration and in the recommended amounts. Never take a pipette or reagents from someone else's bench, as that not only disturbs the proper working of the laboratory, but also can lead to contamination of the reagent. Report any missing reagents or laboratory equipment to the laboratory assistant. Reagents not frequently used are kept on shelves for common use by all the students, and should not be transferred to the individual's bench. Order and cleanliness must be maintained in the laboratory as a whole as well as at individual benches. Paper, broken glass etc., should not be dropped down the sink. Special dust-bins and waste boxes are provided for the purpose.'

It is strictly prohibited to eat in the laboratory.

All observations made during work should be recorded immediately after the particular experiment in a special notebook—the student's laboratory record book. Do not make rough notes on odd bits and pieces of paper.

After a session's work is completed, the main tap of the gasline must be checked to see that it is closed; all test tubes and apparatus must be washed, the reagents should be checked and the bench cleaned up. The apparatus used must be returned to the laboratory assistant.

1.9 The Selection, Care and Use of Dissecting Instruments

The dissecting instruments are most commonly-used equipment in science laboratory. Therefore, caution should be exercised. Select the efficient pieces and use them with proper care.

(a) Within the financial limits, the best quality of instruments should be chosen.

(b) Special care should be taken to see that the blades of the scissors are fixed tightly against each other for efficient work during an incision. The tip of the fine scissors can cut minute objects like hair; the fine forceps can grasp minute objects like hair; the tip of the mounted needles are pointed and not hooked; all the cutting instruments including the razor is sharp and not rusted.

(c) Before dissection, it should be ensured that the specimen is killed or properly anesthesised. The animals should be properly fixed in the tray by pins fixed on the appendages or on other suitable parts of the body. Pins should be placed inclined to the outer side. Vertebrates should be dissected as a rule from the ventral side and the invertebrates from the dorsal side.

(d) It should be noted that dissection is not merely 'cutting', but involves 'finding out and display of organs and systems. In most of the dissection, scissors should be more frequently used in cutting instead of the scalpel, unless the situation so damands.

(e) The fine pointed scissors are delicate and should not be used for primary incission of larger animals or cutting tough skin, hard parts or larger organs, except in unavoidable situation.

(f) While using scissors during primary incision, or similar situations, the blunt headed blade should go inside the body to avoid the damage of the internal parts.

(g) Bone cutters should be used for cutting bones, removing shells and cutting hard parts.

(h) The fine forceps are also very delicate instruments and should not be indiscriminately used when the coarse forceps can do the job.

(i) The part to be removed should be 'lifted' by the forceps before cutting to avoid damage of the neighbouring parts.

(j) The seeker (and not the mounted needle) should be used to displace the organs to get a view of the underlying ones, wherever required.

(k) The tips of the fine scissors, fine forceps and the mounted needles should always be checked before use to see whether they have developed any fine 'hook' at the tip. Such defects often spoil good dissection at a crucial stage.

(l) The cutting edges or pointed tips should never be allowed to rub or strike against rough or hard objects to blunt them.

(m) The instruments which are not in use at a particular moment should be kept at a carefully chosen place on the table (say, on the side of the tray opposite to the dissector), so that they do not prick or cut the user or his colleague through inadvertance.

(n) In case of microscopical sections of plant where parts are dissected by a razor, the razor should be held horizontally in proper grip with the plane side of the razor facing downward. A few drops of water should be put on the cocave (upper) surface of the razor.

(o) Wash, clean and dry all the instruments after use and keep them smeared with a thin layer of grease or white petroleum jelly to prevent rusting or corrosion. The grease should be wiped off before use of the instrument.

(p) Syringes and hypodermic needles should be properly cleaned, dried and sterilised by boiling and wiped with rectified spirit before and after use.

A fine wire should be kept inserted inside the hypodermic injection needles.

(q) In case of injections (or puncturing), care should be taken to choose the suitable place in the body for the injection—intramuscular or intravenous. A training should be taken under the guidance of a method-master.

1.10 Methods of Humane Killing

Animals should be killed and properly anesthesised before dissection or similar work. The process should be painless and humane as far as possible, more over should be suited for purpose. The methods vary widely depending on the nature of the animal and particular use in the laboratory.

(a) All air-breathing vertebrates and invertebrates can be killed by a prolonged exposure to chloroform vapour (5-20 minutes) or anesthesised by a moderate exposure to ether vapour. The organisms to be treated should be placed in a closed container, and cotton wool soaked in the chemical (chloroform or ether) should be put in the container before closing the lid.

(b) Animals (slugs, snails, jellyfishes) which contract easily, are killed in an expanded condition by keeping them in a dafute solution of chloral hydrate overnight.

(c) Some of the fishes are killed by immersing them in boiled (very hot) water.

(d) Quick-moving minute animals (Cyclops, Daphnia, Cypris, Hydra) can be killed by hot Bouin's fixative jets. The animals should be kept in a watch glass or a small petri-dish with little water in it, before applying the jet.

1.11 Preparation and Handling of Dead and Preserved Materials

(a) Animals meant for museum display require a proper killing (the common methods already stated) and suitable preservation. All specimens should be fully labelled. The common and less costly practice is to place the larger specimens in specimen glass jars and preserving them in 4% formaldehyde. Still better preservative than formaldehyde is 70% ethanol which causes less corrosion.

(b) Before putting them in the jar, the specimen may be suitably tied to a glass sheet of appropriate size, in a properly displayed condition. The specimen along with the glass sheet are to be placed in the display jar.

(c) The lid or cap of the jar should be tightly closed or sealed. Periodical check is necessary to refill the preservative medium that has evaporated out so that the specimens do not become dry.

(d) The preservative medium should periodically, say once a year, be changed.

(e) For minute specimens, the properly killed specimen (as already stated) should be stained with Eosin, light green, etc. and a whole mount of microscopical preparation should be made.

(f) Specimens should be properly displayed in the museum rack.

(g) Microscopical slides should be kept in slide cabinets or suitable boxes.

(h) For museum display, the insects, spiders, etc. are used as dry preparations. In such cases, the live specimens are killed in 'poison bottles' and dried on a grooved cork tray. The bodies of the animals are carefully placed on the groove and a pin is inserted through the thorax; the wings and legs are arranged for display. Thin paper strips are stretched tightly over the wings which are fixed with pins at their ends, so that the wings are not damaged. The specimens are then to be air dried. After they are dry, each specimen is freed by removing the paper strips and taken out along with the pin on the body. Then they are fixed on the insect display trays or boxes suitably labelled. Naphthalene balls or suitable disinfectants should be added to the tray periodically.

(i) Other museum preparations such as stuffing of animals (for vertebrates), Alizarin preparation (for display of the skeletal system in *situ*), Bioplastic preparation, etc. needs special training.

(j) The methods of skeletal preparation of vertebrates are also simple and can be mastered with a little practice. For skeletal preparation, a killed specimen is to be taken, and the viscera and skin are to be removed by dissection, carefully avoiding the damage to any skeletal structure. The specimen is then boiled in 5% KOH aqueous solution till the muscles have softened down for easy removal. After cooling, the skeletal parts are cleared of muscles and other tissues with the help of forceps. After the skeletal parts are clear, they are to be sundried for a day. They are then bleached by rinsing in hydrogen peroxide and dried. For preparation of articulated bone, the individual pieces prepared as above are to be fixed to one another by a quick-fixer according to their spatial position.

(k) Simple method for counting cell :

  (1) For counting the cells in a cell suspension or in blood, the help of the 'Hemocytometer' should be taken. The details may be found in a textbook dealing with human physiology.

  (2) Cell counting can also be done with the help of graphed-stage micrometer, in a smeared slide. Rough counting of cells can be done by counting the cells in 10 different 'fields' of the slide chosen at random and averaging them.

1.12 Measurement of Growth by Determining the Increase in Length or Total Weight

(a) The growth in length of the aerial parts of a plant can be determined with the help of an auxanometer.

(b) The regional growth of a plant in length can be measured by putting ink marks at equal

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distances apart and then measuring the distance between the points at desired intervals.

For use of this simple technique for roots, the seedling should be grown in sawdust. The sawdust has to be carefully removed by gently washing off with water for marking and measuring each time. Indelible ink should be used.

(c) Direct measurement can be used for all plants and animals. The specimen in case of animals should be properly anesthesised.

(d) Small animals can be measured by placing them in a narrow graduated tube.

(e) The growth in thickness can be measured by comparing periodical readings obtained from directly measuring with a measuring tape (for larger specimens), or by slide callipers (for smaller specimens).

(f) Surface area of leaves, etc. can be measured by taking the outline on a graph paper.

(g) Growth in total weight can be measured by directly weighing the specimen at intervals.

1.13 Safety Measures in Science Laboratories

General Remarks :

Work in science laboratory demands special attention to safety rules. Posters illustrating safety measures are usually hung on the walls of science laboratory.

Various injuries can result from improper handling of glass apparatus, reagents, or equipment. Most accidents are due to carelessness and a failure to observe the elementary laboratory safety rules or insufficient knowledge of the properties of the materials being handled. The spilling of acids or other reagents can spoil or damage one's clothes. Therefore, it is necessary to wear laboratory coat.

There should always be two towels ready for use: one for the hands and another for glassware and apparatus. Never use the same towel for drying hands and apparatus, as this can lead to poisoning, especially when working with chemicals.

The laboratory assistant should always keep his hands clean. Hands should be washed carefully each time after they have come in contact with chemicals. Frequent cases are known where poisoning resulted from chemicals getting under the nails and from there into food.

1.14 Precautions when Using Dissecting Instrument : Razors, Syringes, Hypodermic Needles, Sterilisers, fixatives and other toxic reagents

A large number of biological studies involve the use of dissecting instruments : razors. syringes and hypodermic needles. Careless handling and use of these instruments may prove hazardous to the pupil, teacher, or to the instruments. The correct use can be mastered through direct experience alone. A few hints may be mentioned to help the laboratory-assistant.

(a) All kinds of care should be taken to see that the cutting edge of the dissecting instruments do not rub or strike against any part of the body. Only those items which will be required for a particular dissection should be taken out of the box.

(b) The dissecting instruments (which are not in use at the moment) should not be kept in the dissecting tray at the time of dissection.

(c) The dissecting instruments should be carefully kept in a convenient spot (usually on the side of the tray opposite to thc trainee's seat) so that they may not prick or cut the trainee or his colleagues by inadvertence while working in the laboratory.

(d) Rust and dirt on the instruments should be cleaned before use.

(e) Injection syringes and hypodermic needles should be cleaned, dried and sterilised by boiling before and after use every time. Pricking needles should be also sterilised by holding them on the flame just before use.

(f) Before pricking or inserting the needle (for an injection) the part of the body of animals should be cleaned and wiped with cotton wool soaked in rectified spirit.

(g) While sterilising liquid samples in an autoclave or a pressure cooker, the laboratory assistant should ensure that (i) enough of water is there inside the steriliser; (ii) the dissecting instruments are properly plugged to prevent the entry of water vapour inside the container; (iii) the lid of the sterilisers is properly fitted, screws tightened and safety valves are not choked; (iv) pressure does not rise beyond the prescribed limit, (iv) the sterilisers should be opened only when it has cooled down after being switched off.

(h) While using the dry hot chambers, or ovens, for sterilising glass wares, dissecting instruments, syringes and needles, a constant watch should be maintained so that the temperature does not rise above or go below the prescribed level. The chamber should be opened only after it has cooled down. The materials should be brought out by holding them with a clean towel.

(i) All the chemical agents, e.g., alcohol, formaldehyde, chloroform, acetone, ether, acetic acid, potassium dichromate, mercuric chloride, picric acid etc. which are used singly or in various combinations as fixation agents, are injurious to the body tissues of the user also. The following precautions are essential :

(1) None of the above-mentioned chemicals or the fixative preparation should ever be allowed to get into the eye or come in contact with the tender parts of skin.

(2) All the organic chemicals, e.g. alcohol, ether, chloroform, acetone are highly inflammable and should be kept away from flames or fire. These, as well as strong acids should not be inhaled.

(3) Mercuric chloride, potassium dichromate, picric acid etc. should not be allowed to get into the mouth or mix with food and drink.

(4) Fixtatives, or their ingredients should always be kept away from the live cultures or living organisms.

(5) Picric acid should always be stored immersed in water or 70% alcohol and should never be allowed to dry.

(6) Strong acids and alkalies also demand special care for storage and use. The lid of the container should be closed.

(7) Metallic sodium should be stored immersed in kerosene oil.

(8) Liquid ammonia bottles should always be opened only after chilling them for a considerable time.

1.15 The Danger in Handling Live Cultures of Micro-organisms

A large number of micro-organisms—bacteria, fungi, protozoa, etc. produce serious diseases in man.

Strict caution must be taken in the handling of micro-organisms to avoid contact with body surface.

(a) Pathogenic bacteria fungi, protozoa should not be used in a science laboratory/room unless essential.

(b) Cultures should be kept in sealed containers. Sealing of petri-dishes may be done by affixing adhesive tapes round the edges. Culture tubes should also be kept properly plugged during all stages of culture.

(c) The mouth and nostrils should be properly covered with a mask, handkerchief or a towel with proper distnfectant during handling of the micro-organic cultures.

(d) The culture containers, instruments etc. should be properly sterilised after use.

(e) Work micro-organisms should always be done in specially isolated chambers or rooms, and never in an open laboratory room.

(f) Handling of micro-organisms should never be left to students who do not understand the practice of strict precautions.

1.16 Correct Methods of Disposal of Pathogenic Materials, Antisepsis

Dead and putrifying organisms and cultures of micro-organisms are very dangerous source of health hazard. Dead bodies, remains and excreta of living organisms, and cultures of micro-organisms should be effectively disposed of in way that they do not prove hazardous to any human community or other living organisms. Some common methods are given below :

a) Dead bodies, other remains of animals and plants, and soiled litter should be put in plastic bags which should then be sealed and burnt in an incinerator. They should not be directly thrown in open bins or drains.

(b) In the absence of incinerating facilities, the sealed plastic bags should be buried deep in the soil.

(c) Cultures of micro-organisms in petridishes agar or gelatin should be put in autoclavable disposal bags and sterilised before disposal, The sterilised bags or countents can then be safely thrown in refuse disposal bins.

(d) The liquid cultures in bottles should also be autoclaved, and then the contents can be poured gently down the laboratory sink and washed away with water.

(e) If the procedure described above seem to be difficult, the cultures along with the container may be immersed in a known disinfectant liquid for several hours and then may be flushed away with plenty of water down the laboratory sink.

1.17 Correct Handling of Laboratory Animals (and Plants), Danger of Bites and Scratches

(a) Living organisms (as well as plants or plant parts) for the study in a science laboratory/room should be non-poisonous, of normal appearance and in sound health. It should be ascertained, as far as possible, that they are free from infection and disease. Affected specimens should be destroyed and disposed of as mentioned earlier.

(b) Animals requiring living food are ordinarily undesirable for keeping in the school laboratory.

(c) Animals and plants or parts of plants which cause irritation or allergic reactions should ordinarily be avoided. In case it becomes essential, they should not be touched, and should be handled with forceps, gloves, etc, and other precautions should be taken.

(d) Vectors and carriers of diseases should be avoided as far as possible.

(e) Indiscriminate killing and destruction of animals, uprooting of plants, damaging of plants or gardens should be avoided.

(f) Proper permission should be obtained from the managerial authorities before obtaining collection of specimens from tanks, ponds, garden, fields or forests.

(g) Proper labels should be affixed stating the nature of the container, care and precaution that would be needed during maintenance of laboratory animals.

(h) Animals should be maintained in separate animal houses, plants in gardens and greenhouses.

(i) All living animals should be kept in suitably constructed cages or containers so that they do not pose hazard to the organisms or the user, are secure against possible escape of the inmates and against the entry of possible predators and pests, carriers of diseases and infections.

(j) All living animals and plants under care should receive proper physical-environmental care, food and water, The requirement of each species should be carefully ascertained beforehand.

(k) Every item related to the culture and rearing of organisms—cages, containers, water bottles, etc. should be cleaned regularly, applying suitable (non-corrosive) disinfectants.

(l) Provision for proper care should be made for weekends and longer holidays.

(m) All stocks should be inspected for symptoms of ill health, disease and discomfort.

(n) No living organism should be treated, bled or used in a way that may seem to be cruel.

(o) Handling of an organism that has hostile, scratching or biting habits should be done with long forceps, prongs, wearing proper gloves, or in a safe and tranquilised condition.

1.18 Accidents and First-Aid

In all cases of accident, the laboratory assistant should be called at once, except in cases of minor injuries. In cases of special emergency, the student should be ready to administer first-aid to himself and to his mates in the laboratory. In this latter case, the following brief instructions will be helpful:

a) *Burns from chemicals* : When acid or alkali is splashed on hands, face or clothing, the affected area should be washed with a large amount of water, and then with a dilute solution of a substance that will neutralise the chemical. If the contaminant gets into the eye, hold the lids apart and wash immediately with ample water at the eye fountain or with a stream of tap water. Next, use one per cent solution of boric acid if the burn is due to an alkali, and a dilute soda solution if the burn is due to an acid. Finally, apply a drop of olive, castor, or cotton-seed oil (a soothing agent). In all cases of eye injury, the patient should be taken to a doctor.

b) *Burns from hot objects or fire :* Do not use water, but apply an ointment. If necessary, bandage the injured part.

c) *Sodium* : Sodium is a very active metal. Keep it immersed in kerosene or toluene. Wear goggles and use forceps throughout all the experiments with sodium. Handle sodium away from water. Never discard it into the sink.

d) *Bromine* : Work in the hood and always wear goggles in all the experiments in which bromine is used. Bromine is especially quick in producing severe burns on the skin. Therefore, wash at once the injured part of the skin with water and two per cent solution of sodium thiosulphate. Apply glycerol or one per cent solution of phenol. Follow with an ointment.

e) *Phosphorus* : Phosphorus compounds are strong poison. When invested, they may cause death in the first 24 hours. NO ANTIDOTE IS KNOWN FOR PHOSPHORUS. Give the victim a gastric lavage with 5-10 litres of tap water and stimulate vomitting. Give 220 ml. of mineral oil, and then 30 g. of sodium sulphate dissolved in 150 ml. of water.

White phosphorus ignites spontaneously in moist air at about 30°C and causes severe burns that heal slowly.

If any phosphorus gets on the skin or the eyes, remove it by irrigation with tap water for at least 15 minutes.

In all cases of suspected poisoning, give the patient the universal antidote, which is an intimate mixtures of two parts of powdered charcoal, one part of tannic acid and one part of magnesium oxide (a heaping teaspoonful in a half glass of warm water). Call a doctor.

f) *Chlorine gas* : If chlorine gas is inhaled, go at once (or carry the victim) to fresh air. Dampen a handkerchief with ethyl alcohol and hold it to the nose and/or mouth. If the exposure to chlorine has been long (or the concentration of the gas high), consult a doctor.

g) *Hydrogen sulphide* : Take the patient to fresh air. Let him breathe through a cloth wet with chlorinated water.

h) *Cuts* : In the case of cuts or wounds by glass, the hands should be examined and glass fragments, if any, removed from them. The wound should then be washed, treated with iodine and bandaged or covered with a sterile dressing.

i) *Electric shocks* : If a person has received electric shocks, the electric switch should be immediately put off. The patient should be made to lie down on his back and should be allowed to breathe fresh air and should be kept warm. In case the condition is serious, artificial breathing should also be given to him and a doctor should be consulted.

(*j*) *Bites and scratches* :

In case of bites, scratches, or similar injuries, seat or lay the patient down, raise the injured part, clean it with cotton wool soaked in rectified spirit and apply mercurochrome, tincture iodine, tincture benzene or any suitable antiseptic. Then cover the wound with a medicated sticking plaster or a bandage.

(1) In case, of bleeding, after cleaning, a dry dressing of surgical gauze and bandage may be applied.

(2) In case the bleeding is severe, the wound should be rinsed, if possible, and direct pressure should be applied with fingers and thumb. The edges of the cut should be firmly held together. Press a dressing over the wound and bandage properly. Seek medical help promptly.

(3) In case of bites, after the first-aid, the casualty should be taken to the doctor. The animal should be immedlately isolated and watched for a fortnight or so. Any symptom of rabbies or other infectious diseases should be immediately brought to the notice of the doctor.

(4) In case of bites or stings of poisonous animals (e.g. snake, bees, scorpions, etc), efforts should be made to reduce the rapid spreading of the poison through circulation. A few fast ties with a bandage or rubber band above the wounds should be immediately applied and patient should be rushed for medical help.

DISCOVERING FOR YOURSELF

1) What first-aid must be rendered in case of injuries from cuts by glass ?
2) How should spilt concentrated sulphuric acid be removed ?
3) What precautions must be taken when splitting large pieces of sodium hydroxide ?
4) Is it advisable to keep a small amount of a reagent in a large container ?
5) How should solid alkalies or their solutions be stored ? Explain why ?
6) Why are laboratory coat and towels necessary ?
7) What should be done if concentrated sulphuric acid or concentrated alkali solutions get onto the hands or clothing ?

CHAPTER 2

Reagents and Preparation of Solutions

2.1 Use and Care of Reagents

In a science laboratory, reagents are used for conducting experiments and for the synthesis of various compounds.

Reagents can be divided according to their use into two main groups : commonly used reagents and special reagents.

Commonly used reagents are available in every science laboratory. They comprise a relatively small group of chemical substances: acids (hydrochloric, nitric and sulphuric), alkalis (ammonia solution, sodium hydroxide and potassium hydroxide), calcium oxide, barium oxide a number of salts—predominantly inorganic, indicators (litmus, phenolphthalein, methyl orange etc.), some organic solvents (ethyl alcohol, diethyl ether, etc.), and some organic substances (adrenalin, glucose, starch, ethyl alcohol, etc.).

Special reagents are used only for certain types of work.

Reagents can be divided according to their physical states into three types: solid, liquid and gaseous substances.

According to their degree of purity, reagents are divided into Chemically Pure (CP), Analytical Reagent (AR), and Guaranted Reagents (GR). In addition, reagents are classified as commercial grade, purified grade, high purity grade, and spectral grade reagents. For each of these categories, there are established limits of impurities they may contain.

It is necessary to know the main properties of the reagents used in the science laboratory, above all, the degree of their toxicity and inflammability, and whether they can form explosive or inflammable mixtures with other reagents.

Solid reagents on prolonged storage have a tendency to cake, forming hard lumps. Therefore, before sampling a solid reagent, gently tap the closed jar containing the reagent with the palm of the hand. If the reagent fails to loosen, open the jar and loosen the caked mass by means of a glass rod or porcelain spatula. It is not advisable to use a metal spatula for this purpose. Before taking the reagent out of the jar, carefully examine the neck of the jar. Anything that might contaminate the reagent (dust, paraffin, sealing compound, etc.) should be removed. The outer walls of the jar are often coated with salts of ammonia which are usually present in the atmosphere of the science laboratory.

Therefore bottles, jars, and other containers for reagents should be wiped with a fresh damp cloth or towel. It is also recommended that the necks of reagent bottles be covered with a glass cap or small beaker without a lip, so that the edges of the beaker rest tightly on the walls of the bottle.

Solid reagents can be conveniently taken out of jars by means of a porcelain spatula or by pouring them through a wide-necked glass funnel. Liquid reagents should be poured through a glass funnel. Reagents spilled on the bench are inevitably contaminated and should not be returned to the jar. Always try to keep reagents from becoming contaminated — this important rule for handling them should always be observed.

When transferring reagents from a jar to another vessel, it is advisable to place a piece of clean paper, better filter paper, under the reagent jar and under the flask into which the reagent is transferred. All jars and bottles containing reagents must bear a label to indicate the name and grade of reagent, e.g., CP, NaOH. When using a wax pencil, the place where the inscription is to be made is previously warmed with the palm of the hand, or, if the reagent is not inflammable, near a flame (some 15-20 cm. away). Sometimes the reagent bottles are marked with paint. This is done by first painting a background (oval or rectangular in shape) corresponding to the size of the label with white oil paint, and when the latter has dried, the name of the reagent is written on it with a black lacquer.

If a container has no label or inscription on it and the reagent contained in it is not known, this reagent should not be used in work. To prevent reagents from being contaminated, the stoppers of the reagent containers should not be interchanged. Sometimes stoppers, especially ground glass stoppers, are tied to the neck of the containers. Substances that absorb moisture from the air — hygroscopic substances — should be stored in jars closed tightly with stoppers. The stoppers can be made of rubber (if the reagent does not affect the rubber) or, of ground glass (if the reagent is not an alkali). If a cork stopper is used, it should be coated either with paraffin, sealing wax, or varnish.

Reagents which undergo change when exposed to light are stored in brown or dark glass bottles. For example, silver salts darken if stored in bottles made of ordinary glass. Solutions of potassium permanganate, sodium thiosulphate, aniline and many other reagents also undergo change on prolonged storage. Some reagents cannot be stored in glass containers at all. For example, hydrofluoric acid decomposes glass, and is therefore kept in containers made of polyethylene. Polyethylene bottles are translucent, chemically inert and convenient to handle.

For storing alkali solutions, the inner walls of the bottles may be coated with a thin layer of paraffin or ceresin. Stocks of reagents are usually kept in a storage room, the inflammable and poisonous materials being kept separately in special cupboards. Only small amounts of reagents should be kept in the laboratory.

The reagents should be kept in a definite order and in definite places so that when required they could be easily located. Supplies of acids and alkalis, especially their concentrated solutions, are best kept in the exhaust hood. Inorganic reagents are kept separately from organic reagents. Salts are stored in the following manner; it is convenient to put the salts in alphabetical order according to the corresponding precautions. For example, one shelf is used for bottles containing aluminium salts. Within this group the salts can also be put alphabetically according to the corresponding anions. For example, the first bottle contains aluminium bromide, followed by aluminium chloride, aluminium hydroxide, aluminium nitrate, aluminium sulphate, aluminium sulphide, etc. Make a list of all the reagents and assign each reagent a mark, indicating the number of the cupboard and shelf where it is being kept. Thus, for the example given above of aluminium salts, the numerical system can be as follows: 1. Aluminium bromide, cupboard No. 1, shelf 1, row 1; 2. Aluminium chloride, cupboard No. 1, shelf 1, row 2, etc.

Shelves for storing reagents are labelled; each label bearing the symbol of warning is glued near the place where the jars with corresponding salts are kept.

Organic reagents which are not inflammable or injurious to health are also put in alphabetical order according to groups; for example, acids and their salts, alcohols, amines and their salts, hydrocarbons, etc. Liquid reagents are kept apart from the solid reagents.

It is absolutely impermissible to keep reagents which can interact with one another (for example, ammonia solutions and volatile acids, such as hydrochloric acid) next to each other. For the same reason, potassium chloride should never be kept in the same place as charcoal or sugar, etc. On the bench shelves, all reagents are kept in bottles of the same size and shape. The bottles should be so placed that the labels face the laboratory assistant. When pouring the contents from the bottles, care should be taken not to let the contents get onto the label.

To protect paper labels, they can be coated with cellulose acetate varnish or any other transparent waterproof coating, or covered with a transparent adhesive tape.

2.2 Rules for Using and Storing Reagents

1. Reagents should be protected from contamination. If a solid reagent is spilled, it should be carefully put into a separate container. Such contaminated reagents may be used in work that does not involve precise determination.
2. Each bottle containing a reagent should bear a label indicating the name and grade of the reagent.
3. Reagents that can be affected by light are kept in bottles made of brown or dark glass.
4. Work with inflammable chemicals shall be performed away from open flames. As a safety precaution, a fire extinguisher, dry sand, etc., should be kept at hand while work with inflammables is being done.
5. To identify a reagent by its odour, open the bottle containing the reagent and hold it with the left hand at a small distance from the face, then carefully, with the right hand, waft the vapours over the mouth of the bottle towards the nose.
6. Reagents which can react with one another are kept apart from each other.
7. Inflammables are kept in a room/cupboard specially equipped for such a purpose. No supplies of inflammable chemicals should be kept in the science laboratory.
8. Poisonous reagents are kept separately from other reagents.
9. Reagents are arranged in a definite order. A record is kept of all the reagents in separate notebook.

2.3 Discovering for Yourself (reagents)

1. How are reagents classified according to their purity ?
2. What is the correct procedure for taking solid reagents from their containers ?
3. Why is it necessary to labels jars and bottle containing reagents ?
4. Why should the stoppers of reagent bottles not be interchanged ?
5. In what order should reagents be arranged on the shelves ?
6. Is it correct to keep bottles containing organic and inorganic chemicals next to one another ?
7. Should chemicals, which can interact with one another be kept next to each other?
8. How are labels on reagent bottles protected ?

2.4 Solubility of Substances

In a science laboratory, it is important to know how to prepare solutions.

Not all substances dissolve equally well in any liquid. Some substances dissolve readily in water but are insoluble in organic solvents, or, are soluble in organic solvents but not in water.

The solubility of a substance varies with temperature. In most cases solid substances dissolve more readily if the preparation of the solution is accompanied by heating. Gases, on the other hand, dissolve less readily with a rise in temperature.

There is a limit to solubility of solid substances at a given temperature, i. e., only a certain amount of a substance can be dissolved at a given temperature. The solubility of substances can be found in Chemistry textbook for middle schools Part I, NCERT, 1972, or in special handbooks.

2.5 General Directions for Preparing Solutions

Aqueous solutions should be prepared with distilled water in order to avoid contamination by impurities present in tap water.

First, a suitable container (bottle or flask) for making and storing the solution should be selected in accordance with the volume of the solution required. For example, for preparing a 2-litre solution, the capacity of the container should not exceed 2.5 litres. As a rule, the capacity of the container should be a little more than the volume of the solution to be prepared.

The container must then be carefully washed. When preparing large volumes of solutions (5 litres or more) it is best to use two identical bottles, one for preparing and the other for storing the solution.

All flasks or bottles containing solutions must have labels glued onto them, stating the name of the substance dissolved, the concentration of the solution, the date on which the solution was prepared, and the day when it was last checked. One example is given below :

HCL
Hydrochloric acid
0.1N solution
Prepared : **February 12, 1976.**
Checked : **April 15, 1976.**

It is necessary to check the concentration of a freshly prepared solution in order to know whether it has been correctly prepared, and subsequently, to see whether any changes in the concentration have occurred. This is done by determining the density of the solution, or by titration.

2.6 Concentration of Solutions and Ways of Expressing it

Solutions differ from one another in the amount of substance dissolved in them (i.e., in their concentration). Besides, solutions can be approximate or standard, depending on the purpose for which they are prepared.

The concentration of a solution can be expressed in a number of ways.

Approximate solutions: The concentration of such solutions is usually expressed in per cent by weight, i. e., the number of grams of a substance dissolved per 100 g. of solution; or, it can be expressed in per cent by volume, i. e., the number of millilitres of a liquid dissolved per 100 millilitres of the solution.

Standard solution: The concentration of such solutions is usually expressed as

a) normal concentration (or normality), i. e., the number of gram-equivalents of a substance dissolved in 1 litre of solution;

b) molar concentration (molarity) i. e., the number of moles of a substance contained in 1 litre of solution.

2.7 Preparation of Approximate Solutions

The amount of a substance required for preparing a given approximate solution is weighed out on a chemical balance. The weight of a substance (w) in grams required for preparing a given solution (wt. %) can be calculated from the following formula :

$$w = \frac{c \times m}{100} \qquad (1)$$

where c = concentration of solution, per cent

m = mass of solution, g

The amount of water in mililitres required for preparing a solution in this case is (m—w)

Example 1. How many grams of anhydrous sodium carbonate (does not contain water of crystallisation) are required for preparing a 15 per cent solution, i. e., a solution 100 g of which contain 15 g. of sodium carbonate and 85 g. of water ? The required amount is calculated from formula (1)

$$w = \frac{15 \times 2000}{100} = 300 \text{ g}$$

This amount of salt is dissolved in 2000—300=1700 g (1700 ml) of water

For preparing a given volume of an approximate solution, first the density of the required solution is found in a handbook. Then the weight of the substance (w) in grams required for making the given solution is calculated from the following formula :

$$w = \frac{c \times v \times p}{100} \qquad (2)$$

where c = concentration of solution, per cent

v = given volume of solution, 3 ml

p = density of solution, g/cm

This formula is used for calculating the amount of an anhydrous substance (i. e., one that does not contain water of crystallisation) needed for preparing a given volume of a solution.

Example 2. It is necessary to prepare 2 litres of a 15 per cent solution of anhydrous sodium carbonate. The required amount of the carbonate is calculated from formula (2) :

$$w = \frac{15 \times 2000 \times 1.158}{100} = 347.4 \text{ g}$$

where 1.158 = density of 15 per cent solution of Na_2co_3, g/cm^3.

If a solid substance containing water of crystallisation is used for preparing a solution, the mass is calculated from the following formula :

$$w = \frac{c \times v \times p \times M_1}{100 \times M_2} \qquad (3)$$

where c = concentration of solution, per cent

v = volume of solution, ml

p = density of solution, g/cm^3

M_1 = molecular weight of the crystal hydrate (i. e., the solid substance containing water of crystallisation)

M_2 = molecular weight of the anhydrous solid substance

The calculated amount of crystal hydrate is weighed out on a chemical balance, and the solid is then transferred to a previously prepared container. The substance is first dissolved in a small amount of distilled water (usually about 1/3 of the required volume of water). Then the remaining amount of distilled water is added to the solution to make up the given volume.

Example 3. If instead of anhydrous sodium carbonate a salt containing 10 molecules of water of crystallisation is used, the amount of the sodium carbonate required is found from formula (3). To do this, calculate the molecular weight of anhydrous Na_2CO_3 and that of $Na_2CO_3 . IOH_2O$. Since the solution being prepared is an appproximate solution, use rounded-off values in calculating the atomic weights. Hence, the molecular weight of Na_2CO_3 is

$$2 \times 23 + 12 + 3 \times 16 = 106$$

and that of $Na_2CO_3 . IOH_2O$ is

$$2 \times 23 + 12 + 3 \times 16 + 10 \times 18 = 286$$

By substituting these values into formula (3), determine the amount of $Na_2CO_3 . IOH_2O$ needed for preparing the solution :

$$w = \frac{15 \times 2000 \times 1.158 \times 286}{100 \times 106} = 937.6 \text{ g}$$

If the solution is prepared from commercial-grade chemicals, it may be turbid. In this case, the solution is allowed to stand for a while and then filtered. Care should be taken in pouring the liquid not to disturb the undissolved residue in the vessel. To pour off the liquid, it is best to use a syphon.

For preparing approximate solutions of acids, different calculations are required. Since it is inconvenient to weigh out the liquid acids, the amount of acid required is determined in terms of volume rather than weight. To calculate the required volume (v) in ml. For preparing a solution of a given concentration, the following formula is used :

$$v = \frac{v_1 . P_1 . c.}{C. P_2} \qquad (4)$$

where v_1 = volume of the solution, ml

c = concentration of the solution to be prepared, wt. %

C = concentration of the acid solution used in preparing the solution, wt. %

P_1 = density of the solution to be prepared, g/cm^3

P_2 = density of the acid used in preparing the solution, g/cm^3

Example 4. It is required to prepare 2 litres (2000 ml.) of 12.5 per cent solution of hydrochloric acid. The density of the acid available for this purpose is P_2 = 1.185 g/cm^3, which corresponds to 37.27 per cent HCl. From a handbook, we find that the density of a 12.5 per cent solution of HCl is P_1 = 1.060 g/gm^3. By substituting these values into formula (4), we get :

1.

$$v = \frac{2000 \times 1.060 \times 12.5}{37.27 \times 185} = 599.9 \text{ ml.}$$

Thus, to prepare the given solution, 599.9 ml. of the acid are required. Measure out 600 ml. of HCl in a graduated cylinder, and then dilute this acid with water to make up a total volume of 2 litres; i.e., add the acid to 2000—600-1400 ml. of distilled water.

When dissolving mineral acids, especially sulphuric and nitric acid, always add the acid to the water, and never the other way round. When water is added to concentrated acid, a large amount of heat is evolved, and this can lead to spattering of the liquid which causes severe burns.

2.8 Preparation of Standard Solutions

To prepare a standard solution, it is necessary to first calculate the amount of a substance (in grams) necessary for making a solution of the desired concentration.

A normal solution is a solution whose concentration is expressed in gram-equivalents per litre.

The gram-equivalent of any substance is the weight of that substance which in a given reaction combines with, replaces, or is equivalent to 1.008 g. of hydrogen or 8g. of oxygen. The gram-equivalent weight of one and the same substance can have different values depending on the chemical reaction in which it takes part.

The gram-equivalent weight (E) in substitution reactions is calculated by dividing the molecular weight by the acid or alkali number.

The normality of a solution is denoted as N. For the purpose of experiment, solutions having a concentration of IN are usually too concentrated. Therefore, diluted solutions are usually prepared. If one litre of a solution contains half gram-equivalent weight of the substance dissolved, the solution is denoted as 0.5N. If the solution contains one-tenth of the gram-equivalent weight of the substance dissolved, the solution is denoted as 0.1N.

The weight of a substance (w) in grams required for preparing a solution of a given normality can be calculated by the equation :

$$w = \frac{N \times v \times E}{1000} \qquad (5)$$

where N = normality of the solution
v = volume of the solution, ml.
E = gram-equivalent weight of the substance used

To prepare a normal solution, first calculate the molecular weight of the substance to be dissolved and then determine its gram-equivalent weight.

Example 5. We must prepare 500 ml of a 0.1 N NaCl solution.

First calculate the gram-equivalent weight of NaCl. Since the salt is a product of a monobasic acid and monoacid base, its gram-equivalent weight is equal to its molecular weight :

at. wt. of Na = 22.9
of Cl = 35.4
mol. wt. of NaCl = 58.4 or after being rounded off, 58.4

Now calculate the weight of the salt required for preparing the desired solution :

$$w = \frac{0.1 \times 500 \times 58.4}{1000} = 2.9 \text{ g.}$$

This amount of pure salt is weighed on a chemical or an analytical balance. The weighed portion is then transferred into a flask as desired below.

Example 6. We must prepare 1.5 litres or 1500 ml. of a 0.25N solution of barium chloride, using for this purpose $BaCl_2 . 2H_2O$. The molecular weight of $BaCl_2 . 2H_2O$ is equal to the sum of the atomic weights of barium (Ba), chlorine (2Cl), hydrogen (4H), and oxygen (2O) :

at. wt. of Ba = 137.3
,, ,, of 2Cl = 2 × 35.4 = 70.9
,, ,, of 4H = 4 × 1.007 = 4.0
,, ,, of 2O = 2 × 15.9 = 31.9

mol. wt. of $BaCl_2 . 2H_2O$ = 244.2

Since the Ba^{2+} cation carries two positive charges and the 2Cl-anions carry two negative charges it is necessary, in determining the gram-equivalent weight of $BaCl_2 . 2H_2O$, to divide its molecular weight by 2 :

$$244.28 : 2 = 122.1$$

The weight of the substance required for the preparation of the given solution is calculated from formula (5) :

$$w = \frac{0.25 \times 1500 \times 122.1}{1000} = 45.8 \text{ g}$$

The solution is prepared in a 1500-ml flask according to the procedure described below.

To prepare a standard solution, choose a suitable volumetric flask, wash it thoroughly, but do not dry it.

The calculated amount of the substance to be dissolved is weighed out on a chemical or an analytical balance in a previously weighed (tared) watch glass or weighing bottle, but never on paper. The weighed portion may be the calculated amount or an amount close to it, but it must be accurately weighed out on an analytical balance.

Into the neck of a volumetric flask, insert a dry funnel, and pour the weighed-out substance into the funnel, taking care that no material is lost during this process. Then slightly tap the funnel to shake all the particles into the flask. Holding the watch glass or weighing bottle over the funnel with the left hand, carefully wash the watch glass or weighing bottle with distilled water from a wash bottle. Then rinse the funnel thoroughly so that the smallest particles are transferred to the flask. Remove the funnel, and close the flask with a stopper. Shake the flask until the substance is completely dissolved. When not even a tiny crystal remains visible, make the solution upto the mark with distilled water. Close the flask and shake it thoroughly. To do this, hold the neck of the flask with the thumb and middle finger of the right hand and put the index finger of the same hand on the stopper. Carefully turn the flask upside down and then return it to its original position. This is repeated 30-35 times.

Thus, it is not difficult to prepare a standard solution if the substance to be dissolved is a solid, as it is not difficult to calculate and weigh out the amount of the substance needed for preparing the solution. It is more complicated to prepare a standard solution if the substance to be dissolved is a liquid, for example, a mineral acid. In this case, the liquid acid should not be weighed on a balance since this may damage the balance. Instead, such liquids are taken volumetrically. The volume required is calculated from the known mass and density of the original solution.

Example 7. It is required to prepare 500 ml. of a O.1N H_2SO_4 solution. First, calculate from formula (5) the weight (in grams) of the acid needed for preparing the given volume of the solution ($E = 49$):

$$w = \frac{0.1 \times 500 \times 49}{1000} = 2.4 \text{ g}$$

The sulphuric acid usually available in laboratories has a density of 1.8 g/cm^3 which corresponds to 95.7 per cent H_2SO_4. The volume (v) of sulphuric acid (in ml.) required can be calculated from the following formula :

$$v = \frac{w \times 100}{C \times P} \tag{6}$$

where w = weight of the sulphuric acid, g

C = concentration of the acid used for making the solution, %
P = density of the acid used, g/cm^3

By substituting the known values into formula (6), we obtain the required volume of the acid :

$$v = \frac{2.4 \times 100}{95.7 \times 1.8} = 1.4 \text{ ml}$$

Into a 500-ml. volumetric flask, pour about 200 ml. of distilled water, and then through a funnel add carefully (in a narrow stream) the required volume of the sulphuric acid from a 10-ml. graduated cylinder. Then mix the liquid in the volumetrtc flask, allow it to stand for about 20 minutes, and make up to the mark with distilled water. Then, thoroughly mix the solution again.

Preparation of molar solutions. Molar solutions are solutions whose concentration is expressed as molarity. The molarity of a solution is denoted as M which follows the number indicating the concentration of the given solution in moles, for example, 0.5 M. To prepare a molar solution, calculate (as described above) the molecular weight which is usually expressed for the anhydrous substance. The weight (w) of the substance (in grams) required to prepare a solution of a given concentration is calculated from the following formula :

$$w = \frac{M \times M_w \times v}{1000} \qquad (7)$$

where M = molarity of the solution
Mw = molecular weight
v = volume of the solution being prepared, ml.

Example 8. It is required to prepare 500 ml. of a 0.25 M solution of $CuSO_4$. First, calculate the molecular weight of $CuSO_4$, which is 160. The amount (w) of the substance to be dissolved is calculated from formula (7).

$$w = \frac{0.25 \times 160 \times 500}{1000} = 19.9 \text{ g}$$

The salt is weighed out on a chemical or an analytical balance, and the solution is prepared as described above.

2.9 Dilution of Solutions

Sometimes, it is necessary to dilute a concentrated solution. Very often, the dilution is expressed as a volume ratio. For example, a solution diluted two-fold is expressed by the ratio 1 : 1, i. e, to one volume of a given solution must be added one volume of the solvent (e.g. water). If a solution is to be diluted three-fold, the ratio is 1 : 2; i. e., to one volume of a given solution must be added two volumes of water.

Only distilled water is used for dilution. When diluting approximate solutions, the volumes are measured with a graduated cylinder. When diluting standard solutions, only volumetric flasks are used. Two examples, how a solution is diluted are given below.

Example 9. It is required to dilute ten-fold a 0.1N solution (irrespective of what compound). This means that for one volume of the 0.1N solution, we should take 9 volumes of distilled water. With the aid of a pipette, transfer to a 250-ml. flask 25 ml. of the 0.1N solution and then add distilled water up to the mark; i. e., add 225 ml. of water. After this, close the flask and mix the solution thoroughly.

Example 10. We have a 30 per cent solution of ammonia with a density of 0.82 g/cm^3, and must dilute it to an approximately 5 per cent solution, i. e. dilute it six-fold (in a ratio of 1 : 5)

The desired volume of the diluted solution is divided by 6. The value obtained is equal to the volume (ml.) of the 30 per cent solution of ammonia used for the dilution. By multiplying this number by 5, we obtain the volume (ml.) of distilled water required for the dilution.

The solution obtained is checked as follows. Measure the density of the solution which for a 5 per cent solution should be (according to handbooks) 0.97 g/cm.

2.10 Discovering for Yourself (preparation of solutions).

1. How are solutions subdivided in accordance with the accuracy with which they are prepared and the concentration of the dissolved substance in them ?
2. In what solutions is the concentration expressed in per cent ?
3. What are normal solutions ? What are molar solutions ? How do they differ from each other ?
4. What kind of water should be used in preparing solutions in a science laboratory ? Why ?
5. When is it necessary to allow solutions to settle ? What is the purpose of this ? What can be done instead ?
6. Calculate how much of a substance is needed for preparing the following solutions :
   a) 2.5 litres of a 16 per cent solution of sodium hydroxide;
   b) 4.2 litres of a 8 per cent solution of hydrochloric acid, using HCl with a density of 1.17 g/cm^3, which corresponds to 34.1 per cent HCl;
   c) 6 litres of a 12.5 per cent solution of sulphuric acid, using H_2SO_4 with a density of 1.820 g/cm^3, which corresponds to 91.1 per cent H_2SO_4;
   d) 1 litre of a 0.3N solution of sodium carbonate, using anhydrous salt;
   e) 0.5 litre (500 ml) of a 0.1N solution of sodium carbonate, using the decahydrate, $Na_2CO_3 \cdot IOH_2O$;
   f) 100 ml. of a 0.01 N solution of calcium chloride, using the hexahydrate, $CaCl_2 \cdot 6H_2O$;
   g) 1 litre of a 0.25 M solution of NaCl;
   h) 5 litres of a 0.05 M solution of copper sulphate, using $CuSO_4 \times 5H_2O$;
   i) 7.5 litres of a 0.1 M solution of hydrochloric acid, using HCl with a density of 1.170 g/cm^3, which corresponds to 34.18 per cent HCl.
7. What is the correct procedure for diluting solutions ?
8. What volumes of a solution and of water should be taken in order to dilute a solution twelve-fold and twenty-fold ?

CHAPTER 3

General Items for the Laboratory

Various types of glass beakers. funnels, graduated cylinders, pipettes, etc., are indispensable in the science laboratory.

Glassware is made of special types of glass characterised by chemical inertness and thermal resistance.

Sometimes, laboratory ware is made of quartz whose high melting point (1700°-1800°C) and low co-efficient of expansion make it suitable for work at high temperature and involving rapid cooling.

In addition, science laboratory usually has apparatus made of porcelain and other material, such as heat resistant materials as well as transparent and translucent plastic materials.

The most widely used glassware can be divided into three types : glassware for general use, glassware employed for certain specific purposes, and volumetric glassware for measuring the volumes of liquids, solutions and gases.

3.2 Glassware for General Use

Test tubes (fig. 3.1) are glass tubes sealed at one end. The test tubes without lip used in the laboratory have size 150 × 16 mm (L × OD). They are used for performing various experiments and tests involving a small amount of substances. *The boiling tube*, is also about 150 mm long, but wider rather is about 25 mm wide. The boiling tube is used for heating or boiling small quantities of liquids.

The total amount of liquids introduced into a test tube should not exceed half the capacity of the test tube. Reagents inside a test tube are stirred with a glass rod in the following way : hold the test tube at the upper end with the thumb and index finger of the left hand and gently tap the lower end of the test tube, with the index finger of the right hand. *Never shake a test tube containing reagents, covering its open end with a finger*. To heat a test tube, the test tube is held over a gas flame, so that the upper portion of the liquid is heated (fig. 3.2). If the bottom of the test tube is

Fig. 3.1 Test Tube

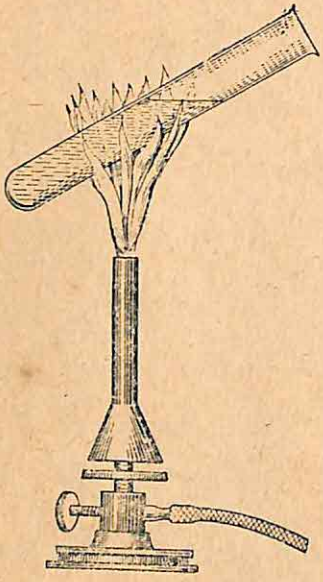

Fig. 3.2 Correct position of Test tube on a gas flame

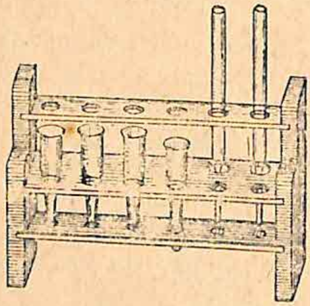

Fig. 3.3 Test Tube Rack

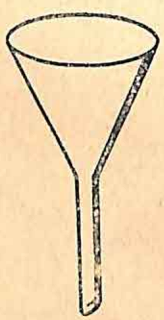

Fig. 3.4 Common Laboratory Funnel

heated, the contents could suddenly boil up and be ejected. To prevent accidents, the open end of the test tube being heated should never be pointed at any body. Test tubes are kept in a wooden rack (fig. 3.3). They are washed with a test-tube brush.

Funnels are available in various sizes and shapes e.g.,

Common laboratory funnel (fig. 3.4) made of polypropylene, 75 mm Dia; *funnel thistle head*, etc.

They are used for pouring liquids from one container to another, in filtration, etc. For this purpose, the funnel is placed into a ring support fastened to a stand. When pouring liquids through a funnel, never fill the funnel to the edge. If the funnel fits tightly in the neck of the flask into which the liquid is poured, the liquid will not flow easily owing to an increase in pressure inside the flask. To reduce the pressure, raise the funnel every now and then, or put a wire triangle (which can be readily made from a piece of wire) on top of the flask and then insert into the triangle the stem of the funnel.

Dropping funnels (fig. 3.5) are pear-shaped or cylindrical in shape. At the upper part of the funnel stem is a glass stopcock. At the top of funnel is an opening which is closed with a ground-glass stopper. They are mostly used in research work where it is necessary to introduce a reagent dropwise or in small portions into the reaction flask.

Separatory funnel is similar to dropping funnels, they are made of thicker glass than dropping funnels and have a much shorter stem. They are used for separating immiscible liquids.

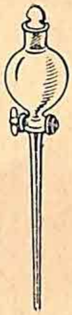

Fig. 3.5 Dropping Funnels

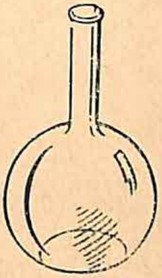

Fig. 3.6 Flat-bottomed Flask

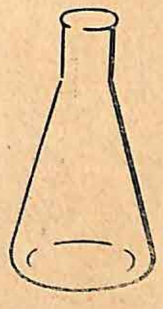

Fig. 3.7 Conical Flask

Beakers are thin-walled cylindrical containers, capacity 150 ml., 250 ml. and 600 ml. made of glass, low form.

Beakers should not be heated directly over a flame or on a hot plate. To heat a beaker, an asbestos gauze should be placed over the hot plate. Beakers are employed for carrying out various experiments.

Flat-bottomed flasks (fig. 3.6), capacity 250 ml. They are used for various purposes and for holding distilled water and solutions. To heat a flat-bottomed flask, it is placed on top of a wire gauze (with asbestos centre 6″×6″) over a hot plate or in a water bath.

Conical flask (fig. 3.7) with narrow mouth (or Erlenmeyer flask) is used for carrying out various tasks, but predominantly for filtration. It may be with or without a lip. Conical flasks made of ordinary glass should not be heated over the open flame.

Suction flasks (fig. 3.8) or *filtering flasks* are used for vacuum filtration. They are made of thick glass, and the upper part has a branch tube for connecting the flask to a vaccum pump. Before using, a new suction flask should be checked by keeping it under reduced pressure for at least 15 minutes. Examine the flask first from the outside. If the glass surface has any scratches, it should not be used for work under reduced pressure since it may break. Following this, close the flask with a rubber stopper, wrap it in a towel or place it in a safety box, and only then connect it to a vacuum pump.

Also check the bench top to see if there are any pieces of metal or hard substances on it which could scratch the bottom of the flask.

Only suction flasks that have been thoroughly tested should be used for work under reduced pressure.

Retorts (fig. 3.9) tabulated are thick-walled vessels designed for heating. They are available in 250 ml. capacity with ground-glass stopper. Retorts are used mainly for distillation at a high temperature and at atmospheric pressure.

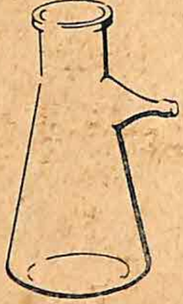

Fig. 3.8 Suction Flask for Vaccum Filtration

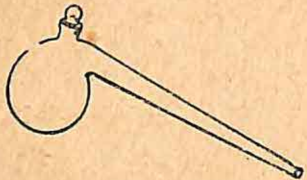

Fig. 3.9 Retort

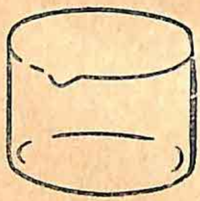

Fig. 3.10 Crystallising Dish

Crystallising dishes (fig. 3.10) with spout are flat-bottomed cylindrical vessels. They are made of thin or thick glass. They are used for crystallisation of substances and sometimes for evaporation of solutions. Crystallisation dishes may be heated only in water bath.

Condenser is used for cooling and condensing vapours formed on heating or boiling of various substances. There are various types of condensers depending on the kind of work being conducted. Mainly, all condensers consist of two parts; a condenser tube of various shapes, and a jacket through which passes cold water which cools the vapours entering the condenser tube from the flask. The Liebig condensers or direct condensers (50 cm and 30 cm) are used for distillation of liquids (fig. 3.11). The vapours on cooling on the walls of the condenser (cooling) tube become condensed to a liquid which flows into the receiver.

When connecting the Liebig condenser to a flask, the following rules should be observed: water should enter the condenser through the lowered bottom inlet and leave the condenser from the lifted upper outlet; the water jacket should always be filled with water. Usually, condensers are assembled as follows : insert a cooling tube into a water jacket, and secure it with pieces of rubber tubing. The cooling tube, before being inserted into water jacket, is lubricated with vaseline. Sometimes the rubber tube is also coated with vaseline inside. The piece of rubber tubing is then tightly fastened with wire to the cooling jacket so that the water jacket will not leak when filled.

Syphons are devices for transferring liquids from one vessel to another. They may be of various designs. The liquid to be transferred is sucked into the syphon with the aid of a suction pump or other means; care should be taken not to allow air bubbles to appear in the syphon. Then the suction pump is disconnected, upon which the liquid is readily syphoned out. When syphoning, the receiver should be placed on a lower level than the vessel from which the liquid is drawn off.

Wash bottle (fig. 3.12) is used for holding small amounts of distilled water and for

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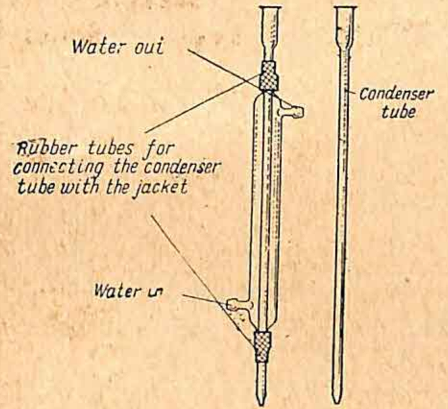
Water out
Rubber tubes for connecting the condenser tube with the jacket
Water in
Condenser tube

Fig. 3.11 Liebig Condenser

Fig. 3.12 Polythene Wash Bottle

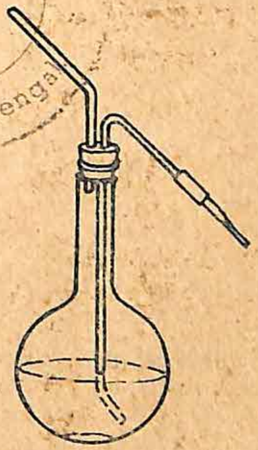

Fig. 3.13 Improvised Wash Bottle

washing precipitates, the walls of a flask, etc. If a polythene wash bottle is not available, flat-bottomed flasks of a capacity of 0.5 litres can be used to make a wash bottle (fig. 3.13). This is how it is done. Select a rubber stopper which fits the neck of the flask. Drill two holes in this stopper. Into one hole, insert a glass tube bent at an acute angle, the bottom end of the tube should almost reach the bottom of the flask, and top end is connected by means of a piece of rubber tubing to a short glass tube with a capillary drawn out at its end. Into the second hole, insert a glass tube bent at an obtuse angle: the end of this tube inside the flask should project no more than 3—5 cm. beyond the stopper.

The flask is filled upto the neck with distilled water or any suitable solution, and the neck is then tightly closed with the stopper. To use the wash bottle, put the tube with the obtuse angle into your mouth and blow air through it, driving a stream of liquid through the tip of the other glass tube.

Bottle, specific gravity, capacity 50 ml. (fig 3.14) : is used as a density bottle and pyknometer. (Ground in stopper).

Bottle, reagent, capacity 250 ml. (fig. 3.15) : made of clear glass with narrow mouth, with polypropylene stopper; unlabelled, is used for putting out liquid chemical on benches.

Bell jar with knob, size 25 × 13 cm. (H × ID). (fig. 3.16) Heavy moulded glass, safe for evacuations, tabulated top to take rubber stopper, ground bottom flange. May be used as air-tight cover for small plants.

Filter pump glass (Pump filter, glass aspirator), fig. 3.17 : is used for creating a partial vacuum in a vessel by means of a water jet. The magnitude of the partial vacuum obtained depends on the water temperature. The lower the water temperature, the greater is the negative pressure that can be obtained with the aid of glass aspirator. The filter

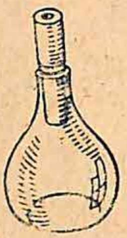

Fig. 3.14 Specific Gravity Bottle

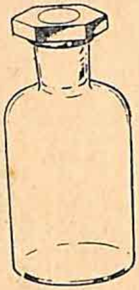

Fig. 3.15 Reagent Bottle

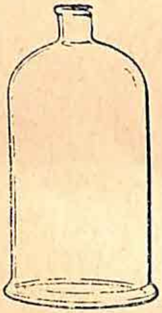

Fig. 3.16 Bell Jar

pump glass is connected to the water faucet via thick-walled vacuum-type rubber tubing. One end of the piece of rubber tubing is fastened with a soft wire to the pump, and the other end to a notched water faucet. Before use, the pump is checked in the following way. The water faucet is gradually opened, and the side tube attached to the vessel from which air is evacuated is closed with a finger. If the finger is sucked in, the pump is in order.

When a suction pump has been used for a long period of time, there accumulates inside it a brown residue of oxides of iron which can clog up the pump. The residue is removed by pouring a 10 per cent solution of hydrochloric acid through the side tube.

3.3 Special-purpose Glassware

Flask, boiling round-bottomed with vial mouth (borosilicate glass), fig. 3.18 : is used in organic and inorganic syntheses and for certain other types of research work. These flasks vary in size (capacity : 200 ml. 500 ml. and 1,000 ml.). Special supports made of rubber or wood or other materials are used, to set a round-bottomed flask on the bench.

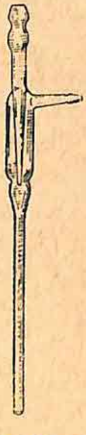

Fig. 3.17 Filter Pump Glass

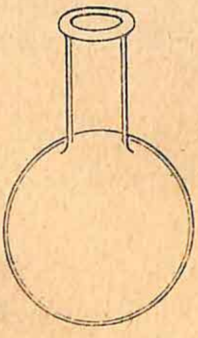

Fig. 3.18 Round Bottomed Flask

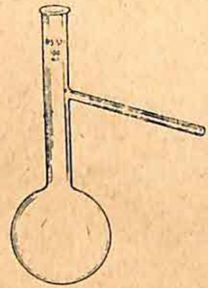

Fig. 319 Wurtz Flask

Distillation flask, capacity 125 ml, with vial mouth (fig. 3.19): These are special flasks used for distilling liquids. They are called by the names of their inventors: Wurtz. Claisen and others.

The distillation flask is a round-bottomed flask with a long neck and a short side tube, extending below top of the neck at 75 degrees. During the distillation, the vapour tube is connected to a condenser by means of a ground-glass joint or a stopper. It may be made of a common flask with stopper and glass tubing.

Desiccator plain, scheibbler, 150 ml. OD. (fig. 3.20): is made of heavy moulded soda glass. A desiccator consists of a glass bowl with a ground-in lid.

Desiccators are used to keep dry substances, microscope lenses, residues etc., as well as for slow drying and for holding substances which readily absorb moisture. The bottom part of the desiccator is filled with a drying agent (desiccant), for example, calcined calcium chloride.

There are two types of desiccators: *the ordinary*, and *the vaccum desiccator*. The latter is provided with a glass stop-cock at the top (in the lid), through which the desiccator is connected to the vaccum pump.

To open a desiccator, never lift the lid, but slide it sideways. The ground-glass rim of the lid and the desiccator should be coated with vaseline. Inside a desiccator, over the drying agent, is placed a porcelain tray for keeping crucibles, weighing bottles, and other vessels in position.

A desiccator should not be left open, since the drying agent inside the desiccator can easily become saturated with moisture present in the air.

Scrubbing bottles are used for scrubbing and purifying gases. There are two types of apparatus which are supplied: Woulfe bottles 500 ml. (fig. 3.21), and tube drying U-shaped 100 × 15 mm. The Woulfe bottles are filled with water, or sulphuric acid, or some other liquid as the liquid absorbent for scrubbing and purifying gases. This bottle also serves as trap in work involving the use of vacuum pumps.

U tubes are usually filled with a solid absorbent.

Gas Generator is the simplest apparatus for preparing gas in a test tube.

The starting substances are placed into a test tube which is then closed with a stopper through which a delivery tube is passed. The shape of the delivery tube should conform to the particular technique by which the gas is prepared, the properties of the gas and the condition in which the gas is utilised. The vessel containing the starting substances is fixed on the stand, and the end of the delivery tube is placed into the gas receptacle. (see improvised Kipp's Apparatus)*

Large quantities of gas are prepared in the apparatus known as Kipp generator, (fig. 3.22). It consist of a lower acid reservoir (3), a central bulb (2) and an upper bulb 1. Stem (8) of the upper bulb almost reaches the bottom of acid reservoir (3). The upper part of the central bulb has tubulus (5) closed by a plug with the delivery tube and a stopcock (6). The lower acid reservoir has a tubulus (4) through which liquid is drained from

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* Chemistry Demonstration Kit Manual, NCERT, 1973.

Fig. 3.20 Desiccator

Fig. 3.21 Woulfe Bottle

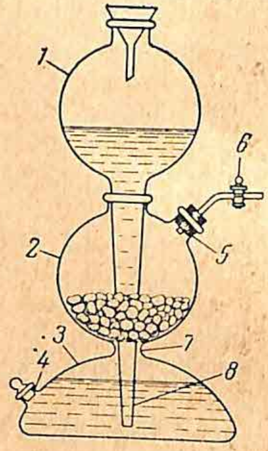

Fig. 3.22 Kipp Generator

the apparatus. Solid substance is charged into the central bulb (2) through tubulus (5). The granule size should not allow penetration of the solid substance into the lower acid reservoir (3). To ensure better safety against solid penetration into the acid reservoir, slit (7) is packed by a rubber gasket through which the stem of the upper bulb (1) passes. It also has small holes to ensure free circulation of the liquid. The tubulus of the central bulb is stoppered and cock (6) is opened. Acid is poured into the generator through the funnel in the upper bulb until the solid in the central bulb is covered with the acid (avoids excessive quantities of the acid). The reaction between the acid and the solid substance in the central bulb begins and the gas is evolved.

Now cock (6) is closed, and if the generator is tight, the acid will be displaced from central bulb (2) into the lower acid reservoir (3) and the upper bulb (1), the reaction stops and the evolution of the gas discontinues.

To liberate another portion of gas, cock (6) is opened and the acid rises into the central bulb (2) to come in contact with the reacting solid. The reaction is thus renewed.

Gas is collected in a receptacle—which may be a test tube. If the gas is to be kept for period of time, the test tube should be closed with rubber stoppers.

The solid substance charged in the Kipp generator should be in the form of lumps not smaller than 1 cubic centimetre each. If powdered material is used, its reaction with the acid will proceed vigorously, and this can lead to an accident. The rate of gas formation in the generator depends on the rate of removal of the gas from the generator. The rate of gas removal is regulated by means of a stopcock on the gas outlet tube, and this in turn, regulates the level of the acid inside the generator. If the stopcork is completely open, gas formation in the reactor will proceed too fast. The gas outlet tube and the stopcork must be kept thoroughly clean. They are cleaned when the generator is being disassembled and washed and the solid substance and the acid are replaced.

To generate carbon dioxide, marble and hydrochloric acid are used. To generate hydrogen sulphide, ferrous sulphide and hydrochloric acid are used. To generate hydrogen, granulated metallic zinc and hydrochloric acid are used.

Before disassembling the apparatus, have a glass or enamel vessel ready for the acid and a large tray for the solid substance. Remove the safety funnel from the neck of the pear-shaped funnel, and close the apparatus with a rubber stopper.

Following this, carefully remove the pear-shaped funnel and then the stopper, and pour the acid in the funnel into the glass jar. Then remove the solid material from the middle part and the acid remaining in the bottom part of the generator. If the bottom part is provided with an acid outlet tube, first pour out the acid through it and then remove the solid substance. Wash the disassembled generator with water, reassemble it, and through the opening for the gas outlet tube charge, put portion of the solid substance. Insert the gas outlet tube, and only after that charge the acid into the pear-shaped funnel.

3.4 Volumetric Glassware

Volumetric glassware is used for measuring the volume of liquids.

Graduated cylinders (Fig. 3.23) are used for carrying out measurements of the volume of liquids which do not call for a high degree of precision. Graduated cylinders may be of various capacities (from 10 ml. to 500 ml.). On the outer wall of the graduated cylinders are etched division lines marked with numbers indicating of the volume in millilitres. Thus, for example, if the level of the liquid in the cylinder is at the line marked 150, it means that the volume of the liquid is 150 ml.

The spaces between the numbers are subdivided into ten parts; this makes it possible to read the volume to the nearest 1 ml. The level of a transparent liquid in a graduated cylinder should be read by the lower part of the meniscus.

Measuring Pipettes (Fig. 3.24) are devices for measuring exact volumes of liquids. They have a bulb in the middle and may be of various capacities (10 ml. 25 ml.). According to generally-accepted standards, the pipettes are calibrated on the basis of the volume of the liquid delivered. Therefore, when emptying the pipette, the liquid which remains inside the tip should not be blown or tapped out. The pipette is filled by sucking the liquid with the aid of a rubber bulb or with the mouth if the liquid is absolutely harmless. Never suck harmful or poisonous liquids into the pipette with the mouth.

First suck the liquid to above the mark. Then close the upper end of the pipette with the index finger of the right hand (the finger should be slightly wetted); then by gentle release of the pressure allow the liquid to flow out slowly. When the meniscus reaches the mark on the pipette, the flow is stopped by pressing down the finger. The level of a transparent liquid in the pipette is determined by the lower part of the meniscus and that of an opaque liquid, by the upper part of the meniscus. When reading the volume, hold the pipette in such a way so that the eye is at the same level as the mark on the pipette. For delivering the liquid, lower the pipette into the flask until it almost touches the bottom, and allow the liquid to flow along the walls of the slightly tilted flask. When all the liquid has drained from the pipette, hold it against the wall of the flask for

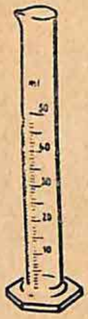

Fig. 3.23 Graduated Cylinder

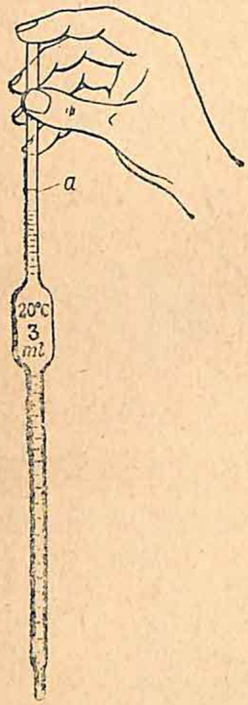

Fig. 3.24 Measuring Pipette
a—Position of the pipette during adjustment of meniscus to the mark on the pipette

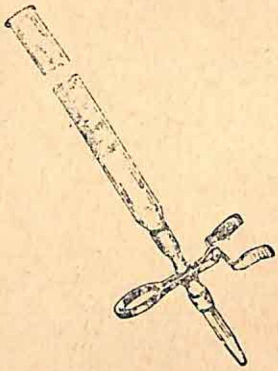

Fig. 3.25 Burette

another five seconds, slightly turn it around its axis and then remove it; do not pay any attention to the liquid remaining inside the tip of the pipette. Before use, the pipette should be thoroughly washed, otherwise droplets of the liquids will adhere to the inner wall and the volume of the liquid measured off will be incorrect. Prior to delivering the sample, the pipette is rinsed with the liquid from a small beaker and then drained.

Burettes (fig. 3.25) are used for taking accurately measured volumes of liquids, mostly in analytical work such as tiltration. They are classified as follows: ordinary, weighing, piston-tube burettes and microburettes. Ordinary burettes deliver volumes to the nearest 0.03 — 0.05 ml. and microburettes to the nearest 0.005 ml. Ordinary burette is provided with Mohr Pinchcock and jet. Its capacity is 50 ml. in 0.1, and tolerance 0.1 ml.

Before use, burettes are fastened to a stand. The burettes are filled with liquids with the aid of a small funnel. First, it is filled to a level somewhat above the zero mark. Then, the funnel is removed and the level of the liquid is adjusted to the zero mark.

If the divisions on the burette become worn out and illegible, they should be blackened. To help one read the level of the liquid in the burette, a simple device can be used;

either draw a vertical line 2-3 mm. wide on a piece of paper or blacken the lower part of the piece of paper. In either case two horizontal cuts are made in the paper and it is slipped on the burette through the two cuts.

To prevent dust from entering the burette, the latter is covered with a small beaker or a short wide test tube. Before use, the burette should be thoroughly washed so that no droplets of liquid adhere to the inner walls, especially above the zero mark. When filling a burette, take care not to allow any air bubbles to become entrapped inside the training tip below the clamp. To remove air bubbles from a burette with pinchcock, turn the draining tip upwards and carefully open the clamp to allow small amounts of liquid to drain out. As liquid goes out, the air bubbles are carried out at the same time. If this is inadequate, proceed as follows: immerse the top of the pipette in a beaker containing the same liquid with which the burette is filled; close the upper end of the burette with a rubber stopper carrying a glass tube and to this tube attach a piece of rubber tubing. Then open the clamp and suck some liquid into the burette.

Volumetric or Graduated Flasks (Fig. 3.26) are used for preparing solutions of exact concentrations. However, since, it is impossible to drain all the liquid from a graduated flask, it cannot be used for measuring out liquids. The flasks are thin-walled (borosilicate glass), flat-bottomed vessels with a narrow mouth. On the spherical part of the flask is etched a number indicating its capacity in millilitres at a certain temperature. The capacity of graduated flasks range from 50 to 1000 ml., calibrated to contain at 20°C. Tolerance 0.2 ml. or 0.6 ml. Graduated flasks are usually provided with polythene or ground glass stoppers, or are made in such a way that rubber stoppers can be used. It is essential that graduated flasks be thoroughly washed so that when mixing solutions in them no drops should adhere to the walls above the graduation mark on the neck. When mixing a liquid in flasks with a capacity of up to 0.5 litre, put the index finger of the right hand on the stopper and hold the neck with the thumb and the middle finger, and then turn the flask upside down 20-30 times. Never hold a graduated flask by the spherical part, for in this case the liquid in the flask will be warmed up by the hand and thus expand, affecting the precision of the measurement. When introducing powdered substances into a graduated flask, use a dry funnel only, preferably one with a short stem. The substance to be introduced into the flask must also be dry. After pouring the solid substance into the funnel, slightly tap the latter to let all the substance get into the flask, and rinse the funnel with water.

Then pour distilled water into the flask through the funnel until the level of the liquid is 1-1.5 cm. below the mark on the neck. After that, remove the funnel and slowly add distilled water drop by drop into the flask preferably with a pipette. Be particularly careful when the water level approaches the etched mark. If the level of water is above the mark, the liquid in the flask is poured out, the flask is again washed, rinsed twice with distilled water, and the preparation of the solution is carried out anew. Do not try to pour out the excess liquid.

3.5 Laboratory Glassware with Standard Ground-glass Joints

Apparatus that can be assembled by means of ground-glass joints are the most con-

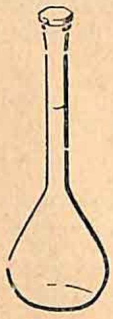

Fig. 3. 26. Volumetric or Graduated Flask

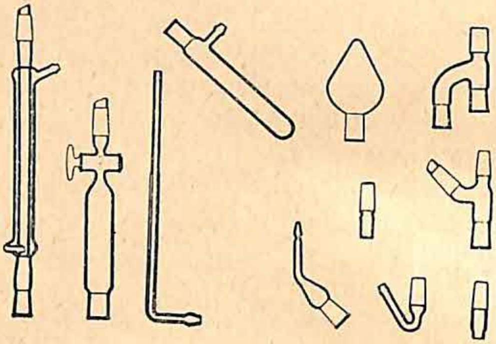

Fig. 3.27 Samples of laboratory glassware with standard ground-glass joints

venient to handle (fig. 3.27). These joints are made to standard sizes so that a broken part of an apparatus or a broken ground-glass stopper can be readily replaced by another with joints of the same size. The size of a joint is determined by its largest diameter. There are also connecting joints which are tubes of various lengths and which terminate with ground-glass joints of different sizes. With the aid of such tubes, it is possible to join two parts of an apparatus, which have ground-glass joints of different sizes.

3.6 Laboratory Porcelain Ware

Porcelain ware can be heated up to approximately 1200°C. Its shortcomings are its lack of transparency and relatively heavy weight. The types of porcelain ware used in a science laboratory are limited and are much fewer than those of glassware.

Porcelain Beakers are of various sizes and may be with or without a handle or a lip.

Porcelain Evaporating Dishes (fig. 3.28) are used for evaporating and heating liquids. They are available in various capacities, with diameter ranging from 30 ml. to 250 ml.

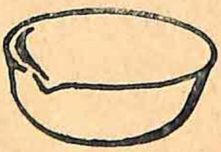

Fig. 3.28 Porcelain Evaporating Dish

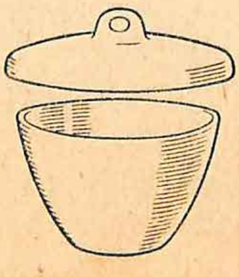

Fig. 3.29 Porcelain Crucible with a porcelain lid

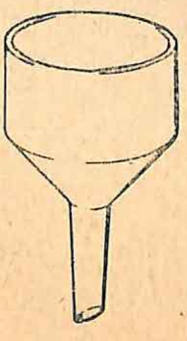

Fig. 3.30 Buchner Funnel

Dish together with lid is glazed both on the inside and outside. Large evaporating dishes are glazed on the inside, and on the outside only along the edge.

Porcelain Crucibles are vessels used for igniting and roasting various solid substances (precipitates, minerals, etc.) as well as for fusing alkalis. They are of various capacities.

The most commonly used porcelain crucibles are those with a porcelain lid capacity 15 ml. (fig. 3.29).

Buchner Funnel (fig. 3.30) 56 cm ID is used for filtering liquids under reduced pressure. A description of how they are used in filtration is given on page Needs filter paper 5 cm. diameter pump or filter water jet, filter flask 250 ml. capacity.

Porcelain Mortar and Pestle (fig. 3.31) are used for grinding solid substances. Filter is drawn through filter paper by vaccum. A description of how they are used in grinding is given on page 79

Porcelain Spoon-spatulas are used for sampling substances, removing residues from filters and for carrying out various other tasks.

Combustion Boat (fig. 3.32) 50 × 10 × 8 mm. (L × W × Depth). Glazed porcelain with handle. Used for holding substances heated in flow of gas.

3.7 Plastic-Ware

Some items is made of transparent plastics. Such items are characterised by chemical stability, sufficient mechanical strength, lightness of weight and convenient to handle.

Syringe—plastic, transparent with capacity 10 ml., graduated in ml. (fig. 3.33). It is used for measuring small quantities of liquid, gas, or to demonstrate pump action, etc.

Bottle—dropping, polythene, capacity 100 ml. (fig. 3.34) with squeeze type screw, top with nozzle. Used for releasing drops of indicator from nozzle.

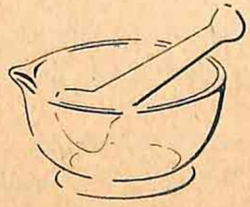

Fig. 3.31 Porcelain mortar and pestle

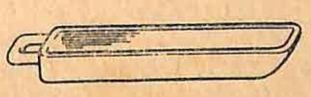

Fig. 3.32 Combustion Boat

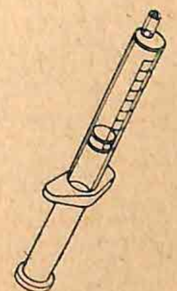

Fig. 3.33 Syringe—plastic, transparent

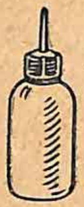

Fig. 3.34 Bottle dropping

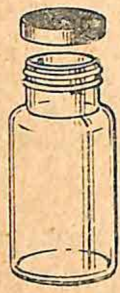

Fig. 3.35 Bottle with wide mouth

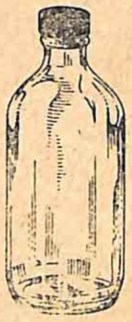

Fig. 3.36 Bottle with narrow mouth

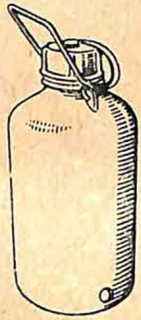

Fig. 3.37 Bottle Aspirator

Bottle with wide mouth, (fig. 3.35): (storage bottle), polythene, capacity 250 ml. with polythene/bakelite screw cap. For storing solid chemicals, etc.

Bottle with narrow mouth fig. 3.36 (Win Chester bottle), polypropelene, capacity 200 ml. Screw cap, use for storing liquids.

Bottle Aspirator. polythene, capacity 5000 ml. (fig. 3.37). Screw cap. Rifflet outlet to fit 6.3 mm tubing, use for storing liquids.

DISCOVERING FOR YOURSELF

1. How should a liquid in a test tube be mixed?
2. Why is it dangerous to warm a liquid in a test tube by placing the bottom of the test tube directly over a flame?
3. What is the difference between a dropping funnel and a separatory funnel?
4. Should a beaker or other thin-walled glassware be heated directly over a gas flame or kerosene stove?
5. Assemble a direct Liebig condenser, fasten it to a stand, and fill the jacket with water. Which outlet of the water jacket should be connected to the water faucet?
6. How should a filter pump glass be attached to a water faucet? How is the water pump checked?
7. How is new thick-walled glassware or apparatus designed for work under reduced pressure checked?
8. Name the flasks used for distilling liquids. Which of these are used for distillation under atmospheric pressure, and which under vacuum? How do they differ from one another?
9. What are desiccators used for? How should a desiccator be opened and closed? Why should the ground glass rim of a desiccator be lubricated? How should a desiccator be carried from one place to another?
10. What are scrubbing bottles? For what purpose are they used? How do they differ from one another?

11. For what purpose is a graduated cylinder used? Take a 250 ml. graduated cylinder and pour into it the following volumes of a liquid: 100, 130, 200 and 250 ml.
12. How should a weighed portion of a solid substance be transferred to a graduated flask for subsequent dissolving? Why must the funnel through which powdered substances are poured be absolutely dry?
13. How should a pipette be filled with a liquid? What is the correct way of pour-out liquid from a pipette?
14. For what purpose are burettes used? What types of burettes do you know? Assemble a burette with Mohr. pinchcock and fasten it to a stand. Fill a burette with water and measure out 3.4, 8.8, 10.0, 16.5 and 25.0 ml.
15. How are air bubbles removed from the draining tip of a burette with Mohr. pinchcock?
16. What vessels are called graduated flasks? For what purpose are they used? How should graduated flasks be filled? Why should a graduated flask containing liquid not be held by the spherical part? What is the correct way of mixing a liquid in a graduated flask?
17. For what purpose is the Kipp generator used? What gases can be obtained with the aid of this generator? What substances should be charged into a Kipp generator in order to obtain carbon dioxide, and hydrogen?
18. What are standard ground-glass joints? What advantages do they afford?
19. Make a wash bottle with glass tubes and a flat-bottomed 250 ml. flask. Into which of the two tubes should air be blown so that water will come out of the other one?
20. Make a syphon from a glass tube and try to syphon water from a glass jar. Can rubber tubing be used for syphoning liquids? How should this be done? In what position, relative to each other, should the container with the liquid to be syphoned, and the receiver be?
21. What are calcium chloride tubes used for? Assemble a calcium-chloride tube for protecting a solution from penetration of carbon dioxide. What absorbents can be used for this purpose?

CHAPTER 4

Some Selected Apparatus

4.1 Biological Microscope

1. *Purpose* :

This microscope is primarily designed for examining minute particles invisible with the unaided eye.

Biological microscope is primarily used for examining transparent bodies illuminated by ordinary light passing through them. But at low magnifications, it can be used for observing surfaces of opaque bodies as well. The field of its usual applications (for educational purposes, in botany and zoology laboratories) can be extended by providing this microscope with special auxiliaries.

2. *Main Data* :

Microscope magnification	× 56 to × 300
"Mechanical length" of microscope tube, mm	160
One revolution of coarse-adjustment knob corresponds to linear travel of tube, mm	20
One revolution of knob of micro-mechanism corresponds to travel of tube, mm.	0.1
Drum of micrometric-mechanism is divided into	50 divisions (one division corresponds to two microns of tube travel).
Thickness of cover glass, mm.	0.17

3. *Optical scheme and operation-principle of instrument*

The construction of this microscope is based on such an arrangement of lenses where the image of an object enlarged with the aid of a lens system (an objective) is enlarged once more with the aid of another lens system (an eyepiece).

By placing the object near the focal point of the objective, a real image, enlarged and inverted, is obtained behind the objective.

When viewed through an eyepiece, as in case of using a hand magnifier, this image is enlarged even to a greater extent, being at the same time virtual and direct. As a result, the microscope, as a whole gives an inverted image, that is an image which is inverted with respect to the object.

Provided that the magnification of the objective and that of the eyepiece are known separately, total magnification of the microscope is readily determined, this being the product of the magnifications of the objective and the eyepiece.

It is known from elementary optics that all the lenses have a number of inherent faults. The faults of the objective affect the final image to a greater extent than those of the eyepiece. Therefore an objective is always composed of two or more lenses mated so as to eliminate the image defects. The eyepiece too, in its turn, is composed of two lenses as with a simple lens alone it should be necessary to increase the microscope tube diameter. The scheme in fig. 4.1 illustrates the arrangement and the operation of the microscope lenses.

4. *Design* :

The Microscope design is shown in fig. 4.2. The main parts of the microscope are as follows : a base, a tube holder, a tube, mechanisms for rapid and slow travel of the tube, an objective table, a diaphragm mount and a mirror with a fork-type holder.

The base of the stand (1)—the horse shoe base—has three bearing surfaces to provide contact with the table, and two joggles to prevent the stand from fall caused by side shocks. The weight of this base keeps the microscope from overturning even in case of horizontal position of the tube holder.

The tube holder (2) hinged to the base is segment shaped. Due to a recess in the middle portion of this segment, the microscope is easily transported and large objects can be placed on its objective table. The "tightness" of the hinged joint movements which ensures the desirable position of the tube may be controlled with the aid of the wrench supplied together with this microscope. Limit screws in the lower portion of the tube holder ensure horizontal setting of the tube. In the widened upper portion of the segment, there is a micro-mechanism for fine focusing of the tube in the direction of the optical axis of the microscope.

The microscope tube (6) consists of several components. There is a sleeve in its lower portion that serves for inserting the objectives into it. The upper portion—the tube—serves for receiving eyepieces.

In order to set the microscope tube at a required distance from the object being observed, that is to focus the microscope for sharpness, the latter is provided with two mechanisms both of them ensuring fine adjustment of the tube travel in the direction of the optical axis of the microscope but with a varying speed.

The mechanism for rapid (or as it is used for "coarse") travel of the tube (4) consists of a rack fixed to the tube and a pinion toothing with this rack. There are knobs on both the ends of the pinion axle. By rotating these knobs, the tube can be rapidly lowered or raised. The construction of the knobs allows free travel adjustment by means of rotating one knob relative to the other. The obliquity of the rack teeth ensures the required smoothness of travel which is however insufficient in focusing a high magnification objective. To achieve this, there is a second mechanism for the tube travel, the micrometric mechanism for (slow or "fine") lowering and raising. After 20-25 revolutions, the retaining mechanism limits the possibility of further travelling. Two hatches on the guide show the limit of the tube travel ensured by the micrometer mechanism.

It should be kept in mind that this mechanism should be used at a definite distance from the mean position of the tube (that is the point on the tube holder should be brought in the middle position between the hatches on the guide) because, when working in extreme positions, the locking mechanism may be damaged due to an excessive pressure.

The tube lowering is carried out by rotating the knob of the mechanism clockwise. This mechanism may also be used in a number of cases for determining the thickness of the object being examined by focusing first the upper, and then the lower plane of the object, and by taking the readings from the drum.

The stage (8) of the microscope is fixed to its supporting bracket and the latter—to the tube holder. The convenient circular shape of the table and its adequate size meet almost all the requirements of the microscope operator.

There are seven holes in the stage : four of them near the edges—for elastic

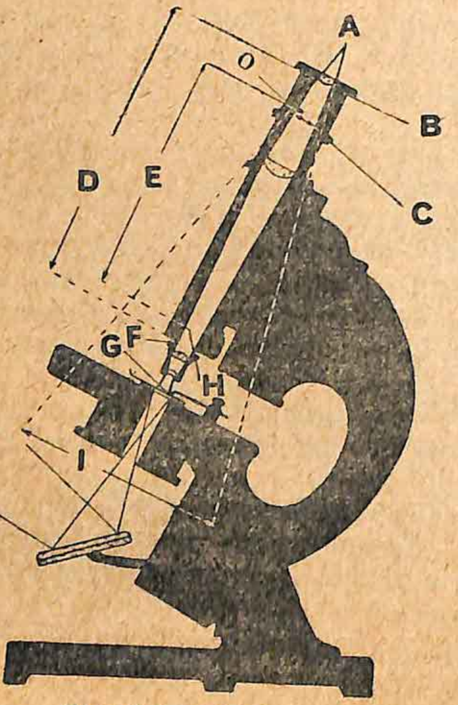

Fig. 4.1 Optical Scheme
A—eyepiece, B—upper tube edge, C—real image, D—mechanical length of tube, E—optical length of tube, F—lower tube edge, G—object, H—back focus of objective, I—virtual image, O—front focus of eyepiece.

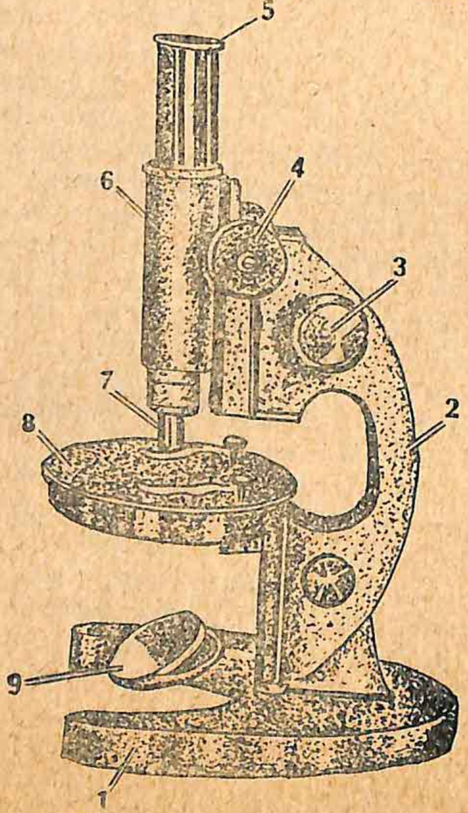

Fig. 4.2 Biological Microscope
1—stand base, 2—arm (tube holder), 3—rough adjustment screw, 4—fine adjustment screw, 5—eyepiece, 6—microscope tube, 7—objective, 8—stage, 9—mirror.

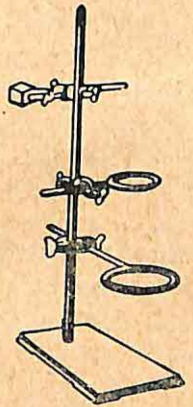

Fig. 4.3 Metal Ring Stand with a set of clamps

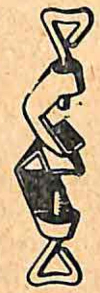

Fig. 4.3 (a) Holder, Extension Clamp

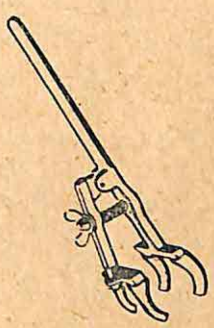

Fig.4.3 (b) Large Clamp for holding condensers, etc.

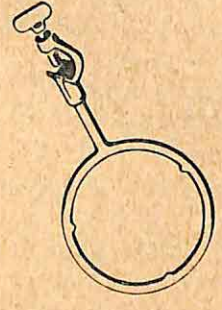

Fig. 4.3 (c) Ring Clamp

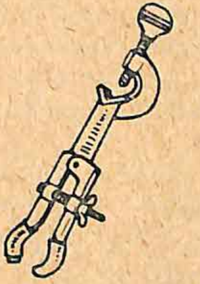

Fig. 4.3 (d) Burette Clamp

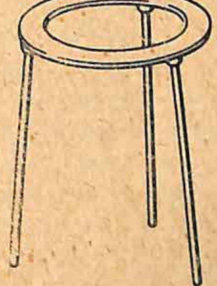

Fig. 4.4 Tripod

clamps of the object to be observed, and the other three—for fastening a removable object carrier.

The bracket under the microscope table carries an elastic cylindrical mount for diaphragms. A set of three diaphragms is supplied with this microscope. The diaphragm having an 1 mm. hole should be used with a 20 objective and that with a 3 mm hole—with an 8 objective. The diaphragm with a 6 mm. hole is used at lower magnifications. A mirror (9) is available for illumination of the object.

Provision is made for rotating the mirror about the axis which makes it possible for the light to be directed in the best way from the light source to the object being observed.

The achromatic objectives (7) of the microscope are designed for normal conditions of operation when the mechanical length of the tube is 160 mm and the thickness of the cover glass—0.17 mm. In this case, with proper illumination, the main values (aperture) of these objectives listed in the table should be applied in full.

Every objective is provided with a special case having a threaded cover to protect the objective from dust. The figure showing the magnification and the aperture of the objective are engraved on its mount and at the bottom of the case.

The design of the Huygens' Eyepieces (5) included into the set of this microscope is such that when one of them is replaced by another, the image remains in the same plane. They enter the eyepiece tube of the microscope smoothly. All the eyepieces have marks to show their magnifications. The microscope is packed in a wooden case.

The microscope case has a door with a lock and a grip on its cover for transportation.

5. *Methods of operation* :

When examining a transparent body, it should be adequately illuminated. Therefore, the microscope must be correctly set relative to the light source, whether a natural or an artificial one. The light intensity should be increased with the increase of total magnification used for the given purpose. The mirror should be uniformly illuminated and direct the light to the object through the hole of the cylindrical diaphragm. The diameter of the illuminated circle should not exceed that required for the given objective as any excessive light would reduce the image quality. With the view of protecting the eye from excessive light, it is recommended to work in darkened room. When working in the daylight, a window facing the north should be preferred because the sun beams can-not get directly on to the mirror through such a window. In work, both eyes should be used alternately, the idle eye being left open which also prevents unnecessary fatigue. The correct position of the operator's body and hands according to the height of his chair and table is none the less important. The position of the microscope on the table and its tilt should be adjusted as well.

With correct illumination, the microscope optical devices ensure total resolution of the object parts according to the aperture of the objective applied.

It is recommended that the correctness of the illumination should be checked with the aid of some well known devices. Test objects would suit this purpose best of all.

The examination of any object should be started with an objective of low magnification which makes it possible to see a larger portion of the object using the same eyepiece, and to choose a place of some interest for a more detailed examination. Having brought this very area near the centre of the visible field of view, one may be sure that in replacing the objective by that of higher magnification, the area will be kept within the field of view.

The focusing (almost a perfect one) of the microscope with an objective of low magnification is carried out with the aid of a single rack mechanism for coarse adjustment of the tube, no matter whether the tube is raised or lowered. In using objectives of high magnification, the coarse adjustment alone is not enough. It may lead to damaging the cover glass and the objective as well as the object to be examined which is sometimes an unique one. Therefore, it is necessary to lower the tube with the aid of the coarse adjustment mechanism until the object almost comes into contact with the cover glass, watching at the same time the microscope objective that is placing the eye at the level of the cover glass. Only after that should the microscope tube be slowly raised with the aid of the coarse adjustment mechanism, looking in the meantime through the microscope eyepiece until the object sought for appears in the field of view. Fine adjustment is carried out with the aid of a fine adjustment mechanism.

During the final adjustment of illumination, the mirror (usually a flat one) which has been set preliminarily in its central position needs but slight correction using the eyepiece.

It is specially recommended to check the uniformity of the back lens of the objective and to make sure of the absence of destructive illumination on the matter inner surface of the tube and its eyepiece portion; this should be done with the eyepiece removed. Sufficiently good results as to the image quality are achieved if a covering about 7/8 of the back lens is obtained provided that the illumination of the latter is uniform. The experiments have shown that if this circle illuminating the lens is eccentric in the objective, i.e., the illumination is incorrect, the objective will not provide complete resolution. Moreover, this sometimes results in the distortion of the fine structure of the test objects and of other regular structures.

6. *Basic Rules for Using Microscope* :
    1. Do not move the microscope from its position or else carry it to another place.
    2. Handle the microscope with great care.
    3. Prepare the object to be examined on a slide strictly following the instructions. The drop should not spread over the glass. The lower surface of the slide should be absolutely dry. Place the slide on the stage under the lens.
    4. See to it that the lens does not touch the liquid or dry preparation. If the lens gets soiled, clean it with a piece of soft cloth or cotton wool.
    5. Direct the luminous flux from the mirror through the diaphragm onto the preparatoin.
    6. By turning the knob of the rack-and-pinion mechanism and by moving the slide under the lens obtain a distinct image of the inspected preparation.
    7. It is forbidden to unscrew and disassemble the objective; otherwise, it will be damaged.

4.2 Metal Apparatus

Widely used in a science laboratory are various metal apparatus, mostly made of steel.

Ring stands with a set of clamps and supports (fig. 4.3) are used for holding condensers, flasks, separatory funnels, etc., in position. Ring supports fastened to the stand

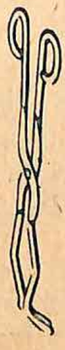

Fig. 4.5 Crucible Tongs

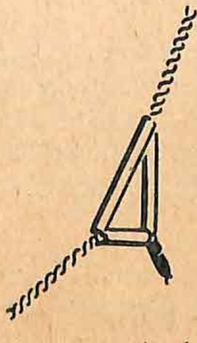

Fig 4.6 Clay triangle

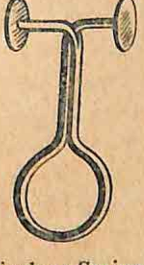

Fig. 4.7 (a) Pinch or Spring Clamps

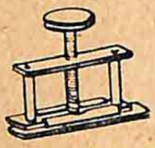

Fig. 4.7 (b) Screw Clamp

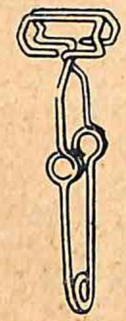

Fig. 4.7 (c) Test Tube Clamp

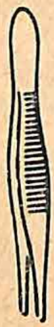

Fig. 4.8 (b) Forceps

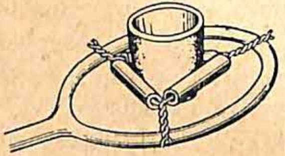

Fig. 4.9 Metal Crucible in a Clay Triangle

are also used for heating ware on an asbestos gauze over a gas burner.

Tripods (Fig. 4.4) are used as supports for various apparatus, flasks, etc., they are especially convenient for the heating of large flasks and other bulky apparatus.

Crucible Tongs (Fig. 4.5) are meant for holding hot crucibles when they are being removed from clay triangles (Fig. 4.6), or in any work involving the handling of hot objects. When not in use, the tongs are placed on the table in such a way that the bent ends do not touch the table surface but face upwards.

Clamps for rubber tubing vary in design. Most widely used in the science laboratory are the pinch or spring clamp, and screw clamp (Fig 4.7 a, b). Pinch clamps (pinch clips) usually used for clamping rubber tubes on burettes without stopcocks because they are convenient for adjusting the rate of flow of liquids. In the fig. 4.7 (c) as shown test tube clamp.

Forceps (Fig. 4.8) are used for grasping small objects and for picking up substances which should not be touched by hand, for example, metallic sodium. Forceps may have various forms and sizes to suit a given purpose.

Metal crucibles (Fig. 4.9), used in various types of analytical work, are made of such materials as steel, nickel, etc. Various precipitates are ignited in such crucibles and dishes. Crucibles made of noble metals should not be used for all types of work, and should be handled with care. Usually, each metal crucible has a lid made of the same metal as the crucible itself. The metal dishes are also used for evaporating solutions in laboratory.

Metal mortars are available in various sizes and are made of cast iron, steel, bronze, etc. Metal mortars are used for grinding only those substances that do not react with the given metal.

CHAPTER 5

Elementary Laboratory Techniques

5.1 Weighing

To weigh a substance is to compare the mass of that substance with the mass of a known weight. The latter is expressed in milligrams(mg), grams(g) and kilograms(kg). The balance is an indispensable instrument in a science laboratory. Practically a lot of work in a laboratory involves determination of the mass of a substance and of the container into which the substance is put.

There are various types of balances for various purposes; (Figs 5.1, a, b, c, d, e, f), for example :

1. Rough balance (accuracy of 1 g);
2. Precision, and chemical balances (with an accuracy of 0.01 g or 0.001 g).
3. Analytical balances (with an accuracy of 0.0001-0, 0.0002 g);

These types of balances are most commonly used in a science laboratory. Most balances have their own set of weights which are usually kept in a special wooden box with a recess for each weight and a pair of forceps for handling them.

1. Rough Balance

There are several types of balances for rough weighing. The double beam balance

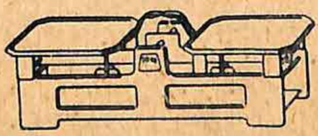

Fig. 5.1a. School Balance, equal arm, capacity 2 kg

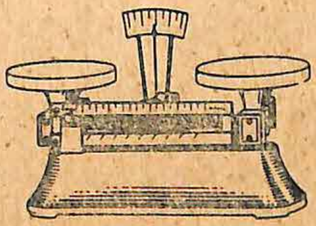

Fig. 5.1b. Balance, double beam, capacity 2 kg.

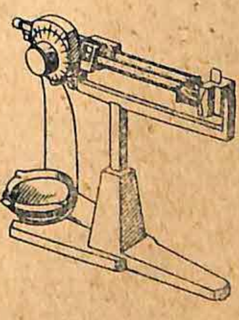

Fig. 5.1c. Balance, dial and double beam, capacity 3 kg.

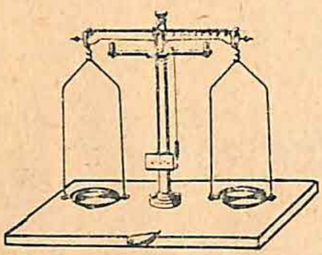

Fig. 5.1d. Balance, beam, semi-analytical, twin-rider

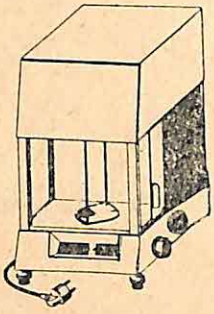

Fig. 5.1e. Analytical Balance

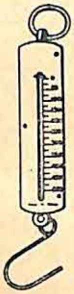

Fig. 5.1f. Spring balance

was designed to weigh substances with a mass not more than 2 kg. Loads exceeding this may damage the balance.

The object to be weighed is put on the left hand scale pan. Never put the substance to be weighed directly on the scale pan, always use a container. Two sheets of paper can also be used for this purpose. When balancing the two pans, if one sheet of paper turns out to be heavier than the other, tear small pieces of paper off the heavier sheet or put small pieces of paper on the other scale pan until the two scale pans are balanced. Containers used in weighing can be counterbalanced with shot, nails, or small pieces of marble. Then pour the substance to be weighed into the counterbalanced container and put the weights on the other scale pan, starting with the largest. If its mass is too great, remove it and replace it by the next smaller weight, and so on until a balance is reached. The sum total of the weights used is the weight of the substance.

If a liquid is to be weighed out, put on the right scale pan a container with a funnel inserted in its neck, counterbalanced with weights or lead shot (on the left pan), and gradually pour the liquid through the funnel.

The weighing of the fuming, poisonous, or malodorous liquids or solids should be carried out in an exhaust hood. The mass of a liquid(m) can be determined without weighing. For this it is necessary to know the exact volume of the liquid (v) and its density (*d*). Conversely, the volume of a liquid can be calculated from its mass by the formula :

$$v = \frac{m}{d}$$

For example, if 500 g. of a liquid of a density of 1.25 g/cm^3 is required, the volume that must be taken is equal to

$$v = \frac{500\ g}{1.25\ g/cm^3} = 400\ cm^3$$

5.2 Precision and Chemical Balance (balance students, twin rider).

The precision balance* allows weighing to the nearest 10 mg, and more seldom upto the nearest 1 mg. Such balances are of various design. The simplest is the dispensing balance whose limiting load does not exceed 100g. It has a beam with a pointer attached to it and directed upwards, two scale pans, and a metal hook which can be put on the index or middle finger, or best, be attached to a support. The weights for such a balance are precise and should not be handled with the hands. They are taken from their box with the aid of forceps with either plastic or bone tips so that they will not become scratched.

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*See Chemistry Demonstration Kit, Instructional Manual, NCERT, New Delhi, 1973.

The most common type of chemical balance is shown in Fig. 5.2. It has a load limit upto 250 g. Unlike balances for rough weighing, the chemical balance has an arresting device and adjusting screws. With the aid of the arresting device, the knife edges of the balance beam and the cushions, when in non-operating position, can be separated from one another. This keeps the knife edges from becoming dull and thus prevents the balance from losing its sensitivity. To bring the balance into the operating position, the handle of the arresting device is turned to the right.

The balance is kept in a place specially set aside for it or on the laboratory bench. The balance is adjusted according to a plummet with the aid of the two front levelling screws (supports). The three supports of the balance two in front and one in the back, should always rest on special metal blocks; usually round, with a small depression in the centre. The supports are placed in these depressions.

Some balances of this type have, in place of a plummet, a liquid level having an air bubble. When the balance is properly placed, the bubble remains in the centre of the circle etched on the glass cover of the level.

If after releasing the arresting device, i.e., when the balance is in operating position, the balance is not in equilibrium, equilibrium can be achieved with the aid of the adjusting screws located at both ends of the beam.

Good chemical balances with riders may be enclosed in a glass fitted case with three doors.

Set of precision weights : These are used for weighing on a chemical balance. The weights are stored in a definite order, each in its own recess, in a wooden box with a lid (Fig. 5.3). The gram weights in the set are usually nickel-plated—tolerance 20 mg. in 100 g. Besides gram weights, the set contains milligram weights. These are flat pieces of metal of various shapes: 10 and 100 mg. weights have the shape of a triangle, 20 and 200 mg. weights, the shape of a square, 50 and 500 mg. weights, the shape of hexagons. The set includes the following small weights: 500, 200, 200, 100, 50, 20, 20 and 10 mg., with lifting tweezers. Weights smaller than 10 mg. are seldom included in such sets.

Weighing : Prior to weighing on a chemical balance, check the plummet to find out whether the balance is properly placed. Also check whether the scale pans are in equilibrium. To do this, put the balance into operating position by turning the handle of the arresting device to the right, and observe the swing of the scale pans. If one of them is heavier than the other, first see if there is dust on the scale pan or any chemical left over from previous weighing. If necessary, wipe the scale pan with a piece of filter paper. If both scale pans are clean, equilibrium is achieved by means of the adjusting screws as described earlier.

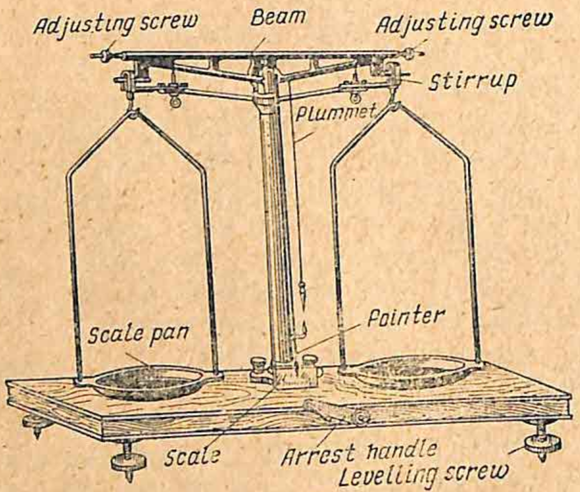

Fig. 5.2. Chemical Balance

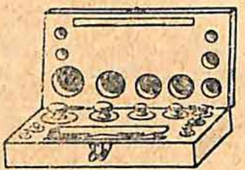

Fig. 5.3. Set of precision weights.

Under no conditions should chemicals be placed directly on the scale pan. The container used for this purpose is counterbalanced as has already been described for rough balances.

When putting weights on a scale pan or removing them, the balance should be arrested, i.e., the balance beam must be raised from the knife edge. The beam of the balance is lowered only during weighing. At the end of a weighing operation, arrest the balance, count the weights and record the result in a laboratory notebook. Then remove the substance that has been weighed from the scale pan, and clean the scale pans. Make sure that the balance is in good order before leaving it.

Rules for Weighing and for Care of Balances:

1. Chemical balances are usually kept in a special weighing room, or on special shelves in the laboratory. Weighing is carried out only after explanation under the supervision of a laboratory technician.
2. All balances should be placed on an even surface which is checked by a plummet or a level.
3. Never shift the balance from one place to another.
4. Handle it with great care and attention.
5. All balances should be kept thoroughly clean and in good order. Balances out of order should not be used.
6. Before weighing anything, check the following:
   a) the levelling of the balance (against the plumb line). If its position needs correcting, adjust it by means of the levelling screws;
   b) the equilibrium of the apparatus, by releasing the pans and seeing that the pointer swings an equal distance each side of the zero reading. Any imbalance should be eliminated by means of the adjusting nuts on the ends of the arms.

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7. Never place hot or greasy object on the pans.
8. Place only weights and substances to be weighed onto the pans, or remove them, when the balance is arrested.
9. Substances to be weighed should be put onto the left-hand pan; reagents should always be weighed on a watch glass, in a weighing bottle, or on paper.
10. All volatile substances, all substances with an unpleasant odour or those harmful to health should be weighed only in an exhaust hood, or put in special containers that can be tightly closed.
11. On any balance, it is prohibited to weigh loads that exceed the load limit of the given balance.
12. Weights should be placed on the right-hand pan and never on the same pan with material to be weighed.
13. Weights should be lifted only with forceps or tweezers and should always be put into their case when not in use.
14. When placing weights on a scale pan, begin with the largest weight and gradually pass on to the smallest. The weights should always be put in the centre of the scale pan.
15. After a weighing operation is completed, the weight is determined first by counting the empty recesses in the box, for weights, then by adding up the weights as they are removed from the scale pan, and comparing the two results. When this is done, the object weighed is removed from the scale pan. Leave the balance clean in proper working order at the end of a weighing job. Never leave weights on the scale pan after a weighing operation is completed.
16. All weighing for a particular job should be done on the same balance and with the same set of weights.
17. When using a balance with an arresting device, the balance should be arrested when the weights and the object to be weighed are placed on or removed from the scale pan. The balance beam is lowered on the knife edge only during the weighing, and is again raised when the weighing operation is completed and when the weights are removed.

REVIEW QUESTIONS AND ASSIGNMENTS

1. What types of balances are used in a science laboratory ? How do they differ from one another ?
2. Define the term *load limit* of a balance. Is it permissible to place on a balance a load exceeding its load limit ? Why ?
3. On which scale pan of a balance should the object to be weighed be put and on which the weights ? When should this order be reversed ?
4. How are free-flowing substances weighed on a chemical balance ?
5. What is the correct procedure for weighing liquids ?
6. Where and how should harmful substances and substances with an unpleasant odour be weighed ?
7. What is the function of the arresting device in a chemical balance?

8. Which doors of balance case may be opened during the weighing operation and which should not be opened ?

5.3 Cleaning, Washing and Drying Laboratory Ware

Prior to use, laboratory ware must be thoroughly washed. Success or failure of an experiment often depends on how well the laboratory ware used is washed. The skill of washing laboratory ware is an important part of laboratory techniques.

As a rule, soiled laboratory ware should not be allowed to accumulate. but should be washed immediately.

Before washing soiled laboratory ware, first remove all the remaining substances from it. Waste containing silver and mercury salts or other valuable substances should not be poured into the sink, but into suitable receptacles. Acid and alkali wastes should never be poured into the sink.

Methods of Washing Laboratory Glassware

There are mechanical, physical and chemical methods of washing laboratory ware. Mechanical methods consist in removing contaminants with the aid of brushes, glass rods, etc. Physical methods, consist of utilising the physical properties of the contaminants or of the cleansing agents employed. Thus, for example, the solubility of the contaminating material in water or the properties of surface-active substances (soap) are utilised for removing fatty deposits.

Chemical methods of washing laboratory ware are based on the ability of some reagents to enter into reaction with the contaminating substances and destroy the latter by converting them to substances which are readily dissolved in water. The method selected for cleaning and washing laboratory ware is determined by the nature of the substance to be removed and its chemical and physical properties.

Whichever method is used, always remember the safety rules and observe them. It should be borne in mind that incorrect procedure can lead to poisoning or burns. It is imperative to know exactly what is inside a vessel before proceeding to clean it. When necessary, take precautionary measures to render the substance harmless before removing it.

Mechanical and Physical Methods

Washing with Water :

In this case, the solubility of the contaminating substance in water is utilised. In most instances, it is best to use hot water (most substances dissolve best in hot water). Washing laboratory ware in water usually involves mechanical action (e.g., scrubbing). The soiled laboratory ware is first washed in water from the faucet, and then with warm or hot water. Undissolved residues or residues adhering to the walls of a vessel are removed by means of test-tube brushes (fig. 5.4), or rubber-tipped glass rods, or with small pieces of torn paper, etc. Never use sand, since it scratches the glass and may cause the laboratory ware to crack during heating. Care should be taken when washing with a test-tube brush not to make a hole in the glassware.

Properly washed glassware must be rinsed two or three times with small amount of distilled water. To check whether a vessel has been sufficiently washed, turn it upside down after it has been rinsed with distilled water, and see how the water drains away. If the film of water on the walls remains continuous, the vessel is clean. If the film breaks into scattered droplets, the vessel is still dirty. In this case, other methods of washing (described below) are used.

Steaming:

Glassware that has been steamed or "washed" with steam is especially clean. In steaming glassware, apparatus of the type shown in fig. 5.5 is used. A jet of steam is directed towards the inner walls of the vessel to be washed for not less than one hour. After steaming, the glassware is cooled and dried without inverting it.

Washing with Surface-active Substances:

For washing laboratory ware, especially that contaminated with organic substances, a 10-15 per cent solution of sodium carbonate, solution of soap and various detergents are used.

Pour into the soiled vessel the washing solution (preferably warm), filling the vessel to ¼ of its capacity; carefully shake the vessel so that its entire inner surface is washed, pour the contaminated washing solution out of the vessel, and then wash it with warm water.

When using surface-active substances for washing laboratory ware, the inner walls of the vessel may be washed with brushes.

Check whether the vessel has been sufficiently washed as described above.

Fig, 5.4. Test-tube brush

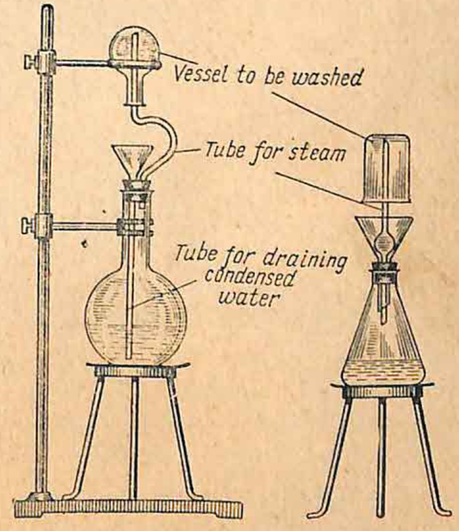


Fig. 5.5. Apparatus for steaming laboratory ware

Chemical Methods

Oxidizing agents, concentrated solutions of mineral acids (sulphuric or hydrochloric) as well as alkali solutions (sodium hydroxide or potassium hydroxide) are very effective for cleaning glassware.

Oxidizing Agents:

This type of cleaning solutions include nitric acid and solutions of certain salts exhibiting oxidizing properties especially in an acidic medium (dichromate-sulphuric acid mixture and potassium permanganate).

Such oxidizers should be used only when other methods fail to give the desired results. In such cases, the laboratory technician should seek the advice of a method-master and ask him to help select the proper oxidizer.

Concentrated nitric acid is excellent for oxidizing inorganic and organic compounds. When washing with nitric acid, utmost care should be taken since it can cause skin burns and may also damage clothes and shoes.

Alkali solutions are used for washing. After washing the vessel with water, it should be rinsed with a 3-5 per cent solution of hydrochloric acid, following which it is again washed first with tap water and then with distilled water. This is done because it is very difficult to wash alkali solutions from the walls of the glassware with water, and therefore the alkali must be neutralised with an acid. If any trace of an alkali remain on the walls of a vessel, this will lead to erroneous results in experiments.

Dichromate-sulphuric acid mixture is prepared by dissolving 5 per cent potassium dichromate in concentrated sulphuric acid. For cleaning glassware, pour this cleaning solution into a vessel which has been previously washed with water, to fill about ¼ of its capacity. Then carefully turn the vessel so that the inner walls are thoroughly rinsed with the solution. After this, pour out the cleaning solution into the container in which it is stored, slowly turning the vessel. Allow the vessel to stand for two or three minutes, and then wash it with water in the usual manner. Sometimes it is necessary to repeat the treatment several times until the vessel is throughly clean. To accelerate the washing process, the mixture can be heated to 40-50°C. The cleaning solution can be re-used many times, until it becomes green in colour. Care should be taken not to let any alcohols get into the cleaning mixture.

Potassium Permanganate Solution:

For washing soiled laboratory ware, a 4-5 per cent solution of potassium permanganate, acidified with sulphuric acid and slightly warmed up, can also be used. Sometimes, an alkaline solution of potassium permanganate is employed instead. In this case, on the walls of the vessel there will remain a brown film which can be removed by rinsing the vessel with a solution of Mohr's salt or ferrous sulphate. Following this, the vessel is rinsed with water in the usual manner.

It is necessary to be extremely careful when working with dichromate-sulphuric acid mixture or potassium permanganate solution.

Drying Laboratory Glassware:

In some cases, after washing, the laboratory ware must be thoroughly dried. Laboratory ware is usually dried at room temperature on a rack with pegs, or on a grid. When a drying rack is used, laboratory ware is put on the pegs and is left there to dry. The pegs are usually previously wrapped in filter paper to prevent direct contact of the laboratory ware.

More convenient for drying laboratory ware is the drying grid which has the openings of various sizes. The laboratory ware is put into openings without the danger of its being contaminated with dust. Air-drying at room temperature is a long process lasting several hours. If necessary, small objects (crucible) can be dried in a desiccator.

RULES FOR WASHING AND DRYING

1. Before washing laboratory ware, all substances in it must be removed.
2. Waste containing valuable substances should not be poured out in to the sink.
3. Laboratory ware washed with detergents must be rinsed with distilled water.
4. When washing laboratory ware with concentrated nitric acid, dichromate-sulphuric acid mixture, or acidified potassium permanganate solution, be careful not to let any of these solutions get onto the hands, face or clothes.
5. After the dichromate-sulphuric acid mixture has become green in colour, it can no longer be used.
6. Always use a rubber bulb for filling a pipette with the dichromate cleaning solution or other oxidizers used for washing laboratory ware.
7. When washed laboratory ware is dried in air, take care not to allow it to become contaminated (it is best to invert the vessels).
8. Washed and dried laboratory ware should be stored in such a way that they will not become contaminated again.

DISCOVERING FOR YOURSELF

1. Which methods of washing laboratory ware are used ?
2. What is the first step in washing laboratory ware ?
3. What should be done with waste containing valuable substances ?
4. Why is sand not used for mechanical removal of substances adhering to the walls of laboratory ware ?
5. Why must laboratory ware be rinsed with distilled water ?
6. When is laboratory ware considered properly washed ? How is this verified ?
7. Assemble an apparatus for washing laboratory ware with steam. Should steam-washed laboratory ware be rinsed with distilled water ?
8. What are the chemical means for removing contamination ?
9. How should laboratory ware be washed when dichromate-sulphuric acid mixture is used ? When does this mixture cease to be effective ?
10. Which is the best way of drying laboratory ware ?
11. How should washed and dried laboratory ware be stored ?

5.4 Laboratory Techniques

Selection and Treatment of Stoppers:

Stoppers used in a science laboratory are made of cork, rubber, glass and other materials.

Cork stoppers are available in various sizes and shapes. The most common ones are conical in shape. Every new stopper, prior to use, should be wiped with a clean towel. Sometimes a new stopper is immersed in boiling water to make it softer and cleaner. This is especially necessary if the stopper has already been used.

In selecting a stopper for a given vessel, look for one that tightly fits in the neck of the vessel (i.e., the diameter of the tappered end of stopper should be slightly bigger than that of the vessel neck on tube). Then the stopper is pressed with the aid of a cork press (fig. 5.6), this makes stopper softer and makes it easier to insert it into the neck of the vessel.

When a stopper is inserted into the neck of a vessel, one-third of the stopper should remain outside the vessel.

To drill a hole in a cork stopper for inserting a glass tube or a thermometer, a special cork borer is used. Borers are brass or steel tubes of various diameters and having a sharp edge at one end. (fig. 5.7). When the borer becomes dull, it is sharpened with a special knife (fig. 5.8). When boring a hole in a stopper, always start with the narrower end of the stopper (fig. 5.9). The borer should be aligned parallel to the axis of the stopper. The opening at the wider end of the stopper must not have torn edges, when the borer approaches the wider end of the stopper, place the stopper on a wooden board and twist it vigorously until it cuts through the stopper. Inside the borer there remains a stem of cork which is pushed out. The stem is not thrown away, but is stored with other stoppers for future use. The hole in the stopper should be slightly smaller in diameter than that of the tube or the thermometer to be inserted. This provides firmness and tightness. The glass tube is lubricated with soap and water, vaseline or glycerine to avoid breaking it when inserted into the hole. A glass tube should always be inserted through the wider end of the stopper. The protruding part of the inserted tube is then wiped with a towel or a piece of filter paper. The correct way of inserting a glass tube into a stopper is shown in fig. 5.10. Sometimes, for better tightness, molten paraffin is poured over cork stoppers fitted into vessels. To do this, the paraffin is melted in a metal spoon or in a crucible,

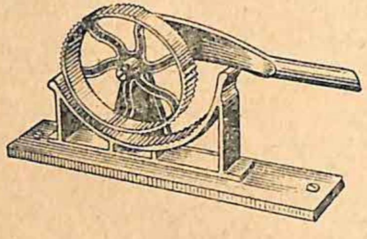


Fig. 5.6. Press for cork stoppers

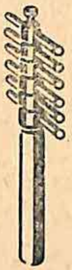


Fig. 5.7. Set of cork borers

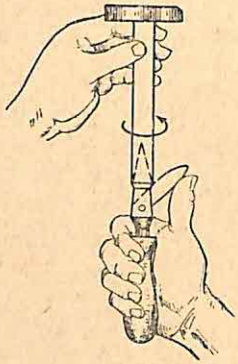


Fig. 5.8. Sharpening a borer with a special knife

and the melt is carefully poured over the stopper and around the edge of the neck of the vessel.

Cork stoppers should never be used for vessels containing concentrated solutions of acids and alkali. These solutions cause disintegration of the cork and would thus become contaminated with the decomposition products. To avoid this, cork stoppers prior to use are boiled in molten paraffin.

Rubber Stoppers :

In cases where cork stoppers are unsuitable, rubber stoppers are used, which can provide better tightness.

However, rubber stoppers cannot be used for vessels containing organic solvents or concentrated sulphuric or nitric acid which affect rubber.

Rubber stoppers are available in various sizes. The talc with which a new rubber stopper is covered should be wiped off prior to use. The stopper is then boiled in a 3 per cent solution of sodium carbonate.

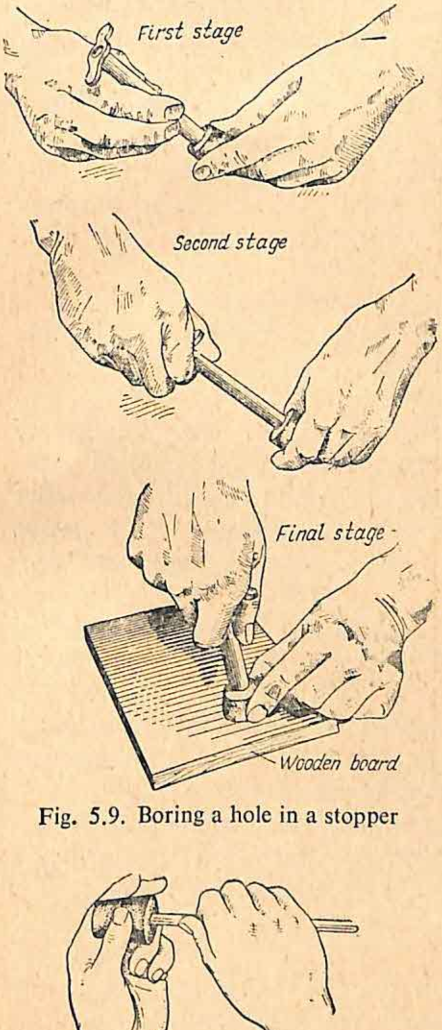


Fig. 5.9. Boring a hole in a stopper

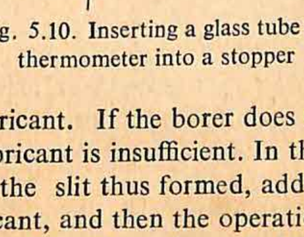


Fig. 5.10. Inserting a glass tube or thermometer into a stopper

For assembling an apparatus with condenser and thermometer, it is necessary to use rubber stopper with holes drilled in them. It is more difficult to bore a hole in a rubber stopper than in a cork stopper. The borer used for this purpose must be very sharp. As in the cork stopper, boring is started through the narrower end. First, mark on the stoppar the spot where the hole is to be drilled. On this spot, put a drop of lubricant, glycerine or mineral oil, and then apply the borer. Alkali solutions should not be used as a lubricant. If the borer does not cut easily, or becomes hot, this means that the amount of lubricant is insufficient. In this case, pull out the borer, slightly squeeze the stopper and into the slit thus formed, add a drop of the lubricant. The borer is also dipped into a lubricant, and then the operation is resumed. When it becomes evident that the borer is approaching the wider end of the stopper, place the stopper on a wooden board, and complete the operation by a vigorous twist of the borer. In some instances, when the borer approaches the wider end of the stopper, it is pulled out, and the operation is completed by drilling from the wider end. This manner of drilling requires some skill. When the boring is finished, the bits of the cork left inside the hole of the borer should be pushed out by means of a ramrod. The stopper with the freshly made hole is carefully wiped with a cloth to remove the lubricant, and after being washed, it is ready for use.

The thermometer or glass tube is wetted with water or smeared with a suitable lubricant before being inserted into the hole of the rubber stopper. The protruding end of the thermometer or tube is wiped with a towel or filter paper. Rubber stoppers can be used in apparatus heated to a temperature not exceeding 180-200°C. However, rubber stoppers cannot be used for vessels containing organic solvents. concentrated sulphuric or nitric acid, which affect rubber.

Ground-Glass Stoppers are an integral part of the glassware or apparatus. Therefore, they must not be interchanged. Each glass stopper is ground to fit the ground joint of a given vessel (for example a stopper from volumetric flasks).

A flask, bottle, or apparatus and its corresponding ground glass stopper are marked with the same number, so that a stopper will turn smoothly inside a ground joint. The ground surface of the stopper is coated with vaseline or special lubricants, depending on the conditions in which the apparatus will be used. To keep stoppers, from getting stuck fast inside joints during storage, the stoppers are wrapped in filter paper and then inserted into the joints.

To dislodge jammed stoppers, tap them lightly with a wooden mallet or a piece of wooden board, or wrap the neck of the vessel in a cloth and run hot water over it, all the time trying to twist the stopper as if unscrewing it.

One of the simplest ways of dislodging jammed stoppers is given below. Around the rim formed by the stopper and neck of the vessel, introduce a few drops of toluene and let the vessel stand for a while. When the ground joint become clear, the stopper can be readily removed. Ground-glass stoppers cannot be used for vessels containing alkali solutions. An open flame should not be used for warming up the stuck stopper if the flask contains inflammable liquids.

Stoppers Made of Other Materials :

Stoppers made of polyethylene are chemically inert to acids or alkalis, but can swell from contact with organic solvents, as in the case of rubber stoppers. Polyethylene stoppers are not recommended for vessels containing standard solutions which are to be stored for a long period of time.

When assembling apparatus for work involving high temperatures, neither cork nor rubber stopper should be used since they are thermally unstable. In such cases, asbestos stoppers are employed. Asbestos fibres or sheets are soaked in water to produce a thick paste which is used either as a putty, or for making a stopper. Stoppers can also be made of cotton wool or other fibrous materials.

DISCOVERING FOR YOURSELF

1. How is a cork or rubber stopper selected for a flask or apparatus? How much of a stopper should protrude from the neck of a vessel?
2. How should a new stopper (cork and rubber stoppers) be treated prior to use?

Take a new stopper and prepare it for use.

3. Can cork stoppers be used for closing vessels containing alkali solutions? What kind of stoppers should be used in this case?
4. How can cork stopper be treated so that it will not be affected by acids or alkalis?
5. How can a vessel be made tight when a cork stopper is used? What substance is used for this purpose?
6. Can rubber stoppers be used in vessels containing concentrated acids, especially sulphuric or nitric acid?
7. Can rubber stoppers be used for closing vessels containing organic solvents? What kind of stoppers should be used in this case?
8. Can cork or rubber stoppers be used in apparatus to be heated to 150° C and more? Why?
9. What material can be used to replace cork or rubber stoppers in apparatus that is heated to high temperatures?
10. How is a cork borer sharpened?
11. How is a hole bored in a stopper?

5.5 Glass Tubes and Rods

Cutting Glass Tubing and Glass Rods:

To prepare simple laboratory apparatus, it is necessary to be proficient in cutting and drawing out glass tubes, rounding of the ends and making capillaries. Therefore, it is necessary to learn how to cut glass tubes and glass rods to the required lengths. The method of cutting depends on the diameter of the tube or rod. If it does not exceed 5-6 mm, first make a cut at the point of the desired length with a triangular file. Wet the cut with water or a weak alkali solution. The tube is then taken in both hands in such a way that the thumb nails are over the scratch (fig. 5.11), slightly bend it from the side opposite the cut, at the same time try to pull it apart. Tube ends are rounded off on a non-luminous flame until they become smooth. When the burner flame becomes yellow, this is a sure sign that the edge melting has begun.

Large-diameter tubes and rods are cut by a different method. At first, make a cut on the tube or rod as in the case described above. Then take another glass rod and heat it in a flame until it is red hot, and with the hot end of this rod touch the cut (previously wetted with water). If no crack appears, remove the heated glass rod and blow on the cut. After a crack appears, the tube or rod either breaks off by itself or can be easily broken off. Sometimes, for cutting tubes or rods having a large diameter, it is better to make a cut all around the tube or rods, then touch the cut ring with a red-hot wire loop. This causes a deep crack to appear and the tube or rod can be easily broken. The cut ring is wetted with water before the heated wire is applied to it.

In all cases, the cut edges must be fire-polished, or the sharp edges filed down.

When cutting glass rods or tubes, protect your hands with a towel.

Bending Glass Tubing: Bending tubes requires some skill. Tubes are best bent over a

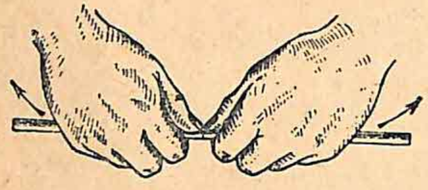


Fig. 5.11. Position of hands when breaking scratched glass tube

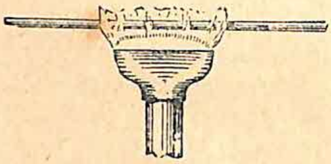


Fig. 5.12. Dovetail nozzle

gas burner with a dovetail nozzle (fig. 5.12). This produces an extended flame which covers the required length of tube. While continuously rotated, the tube should be heated until it softens, it is then held at one end and allowed to bend under its own weight. Short pieces of tubing are bent in the following way. One end of the tube is sealed with a piece of asbestos. The tube is then heated while being rotated; the spot to be bent must be kept constantly in the flame. When the glass becomes soft, the tube is removed from flame and quickly bent to the desired angle; while gently blowing air into the open end of the tube with the mouth. The tube should be bent upwards and towards the person who is bending it. In fig. 5.13 a good bend (A), and bad bends (B and C) are shown.

Hot tubes should not be put directly on a wooden bench top. To anneal a heated tube, it is kept in luminous part of a burner until it is completely coated with soot, and then, it is placed on an asbestos sheet and cooled slowly. Heated glass should be protected from drafts.

Sealing Glass Tubes : To seal a tube, first join one end of it with a piece of tubing of the same type of glass. To do this, the two ends to be joined are heated until red hot and then pressed together. The tube to be sealed is then heated slightly above the point where it is joined to the second tube, constantly rotating the tubes in the flame. When the heated spot becomes red hot and soft, the second tube is rapidly drawn out and the narrow 'tailing' is broken off. The broken end of the tube is then fire polished. During fire polishing, the opening becomes sealed. While the tube is being heated, the glass is allowed to soften, and then air is gently blown from the mouth into the tube to give a smooth round shape to the sealed end. To draw out a tube, first, heat it slightly over a flame, then introduce its middle part into the outer cone of the flame, and, while rotating it between the thumb and index finger, heat it until it softens. Now remove the tube from the flame and stretch it slowly outwards in both directions, until it is of the required diameter.

To draw out a capillary tube, a piece of glass tubing is heated until red hot, and then removed from the flame and the two ends are pulled apart quickly.

DISCOVERING FOR YOURSELF

1. Why is it advisable to use a dovetail nozzle when bending glass tubes ?
2. Why is it advisable to blacken the heated part of a tube over a smoking flame after treating it in a non-luminous flame?

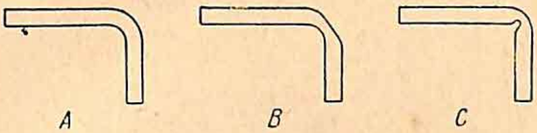


Fig. 5.13. Bent glass tube

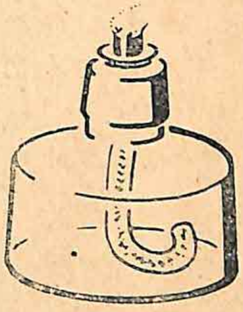


Fig. 5.14. Alcohol Burner

5.6 Heating

Heaters

Heating can be carried out with liquid-type burners working on alcohol or kerosene. with gas burners, with electrical heating equipment, such as hot plates, ovens etc.

Liquid Type Heaters :

Alcohol Burner : Capacity 65 ml. (Fig. 5.14) working on methylated industrial spirit (alcohol) is the simplest type of heaters. The body of an alcohol burner is a reservoir made of thick glass or brass. In the neck of the reservoir is a spare loose-spun cotton wick 20 cm. long through which alcohol diffuses from the reservoir. The neck is covered with an air tight metal or ground-glass cap to prevent evaporation when not in use. To light the burner, remove the cap and light the wick. To put out the flame, return the cap to the neck of the burner. Alcohol is poured into the reservoir through a small glass or polythene funnel inserted into the neck, either with the wick removed or only pushed aside. An alcohol burner may need tripod (150×75 mm). Kerosene stove, pressure type, capacity 1.2 litres is supplied with funnel.

Gas Burners : In some science laboratories, gas is an important fuel for heating various equipments, Bunsen burner is one of these.

Bunsen Burners (Fig. 5.15): There are two types of Bunsen burners : those with and those without a colour for regulating air intake. The Bunsen burner consists of a 11 mm. diameter flame tube fastened to an enamelled base and a side branch for gas delivery. In the lower part of the tube near the gas inlet are two openings for air intake located opposite to each other. For regulating air intake, some Bunsen burners have a collar (with two holes) round the lower part of the tube (where the two holes for air intake are located). This collar is turned so that the holes in it coincide to a greater or less extent with the holes in the tube. The amount of air entering the burner determines the temperature of the flame. When the openings are closed, a cold flame is produced which is lumi-

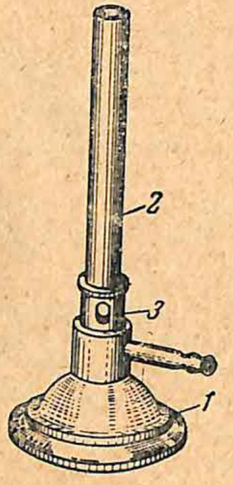


Fig. 5.15. Bunsen Burner

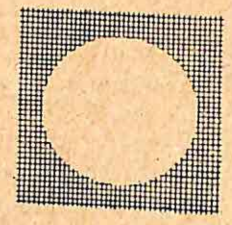


Fig. 5.16. Wire gauze with asbestos centre

nous and sooty. When air is admitted through the holes, the flame will become less luminous, and finally, the flame will become only slightly blue or practically colourless. This is known as the hot flame. When gas is burned with air being admitted, the burner emits a certain sound. Before igniting a burner with a collar for regulating air intake, turn the collar so that the holes are completely closed. Then hold a lighted match near the upper part of the tube and open the gas tap. When the gas is ignited, the collar is gradually turned and air is allowed to enter. The size of the flame on a Bunsen burner is regulated with the aid of the gas tap.

Bunsen burner needs 50 cm. of tubing (6.3 mm dia) and flame spreader or dovetail nozzil to make a wide flame for glass bending.

Sometimes, the flame in a gas burner strikes back, i.e., the gas burns inside the tube. A burner which has struck back gives a green coloured flame sometimes accompained by a whistling noise. Such a burner should be turned off immediately and the burner tube cooled by means of a rag (changing it several times). The burner can be used again only when it has cooled completely.

Electric Heaters : Electric heaters are convenient to use. Commonly employed in a laboratory are electric hot plates with a sealed or open heating element. Each heating appliance is designed for a certain voltage (220 v) and should therefore be connected to the correct electric supply line.

When using hot plates with an open heating element, care should be taken not to allow liquids to get onto the heating element, since this may cause it to burn out.

Heating : Heating can be carried out directly over an open flame, on a wire gauze with an asbestos centre in water, or through sand baths. Heating over an open flame is usually carried out when calcining substances in crucibles made of porcelain, fireclay,

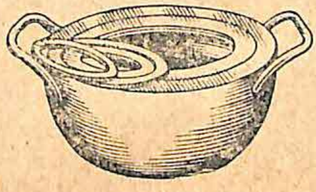


Fig. 5.17 Hot-water Bath

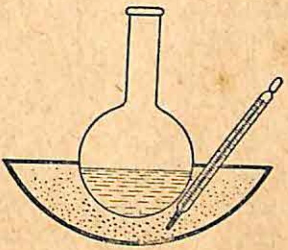


Fig. 5.18 Sand Bath

nickel, steel or other metals.

Heating laboratory glassware, such as flasks, beakers etc, over a direct open flame is not recommended, since this may cause cracking of glass. In most cases, it is best to use a wire gauze 15 cm. square, tinned iron wire with turned edges, with an asbestos disc. 10cm. dia (fig. 5.16). The gauze or sheet is put on a tripod or a support ring stand. The vessel to be heated is placed on the asbestos gauze, and the burner below it. The flame in this case does not touch the vessel directly. The asbestos gauze provides even heating of the vessel. Special care should be taken when heating organic and inorganic substances which are inflammable or readily undergo thermal decompositon. Such substances should not be heated with gas burners. Various kinds of baths are used instead. These baths are flat-bottomed vessels filled with a heat transfer agent. The most common agent used is water. With water, the mnximum heating temperature that can be achieved is about 95° C. Other heat-transfer agents used are sand, air, etc.

Hot Water Baths (fig. 5.17), usually contain boiling water. However, since water evaporates during boiling, it is necessary to see that the proper water level is constantly maintained. When heating inflammable substances, the water in the bath is first brought to the boiling point and then the flame is turned off. The vessel to be heated is lowered into the hot water. From time to time, the temperature of the water is checked with a thermometer. If the temperature drops below the desired one, the water in the bath is replaced with water heated in another place some distance away.

Bath, Sand, Shallow Form : 15 cm. dia (fig. 5.18) is heated with a gas burner or an electric heater. The sand should be previously sieved and then calcined in a hood in order to burn out any organic admixtures it may contain. It is best to use white sand for this purpose. The vessel to be heated is buried in the sand so that the level of the substance inside the vessel is somewhat below the level of sand in the bath. A theremometer is put into the sand next to the vessel. In a sand bath, the heating temperature ranges from 200to 250 °C.

Calcination: Another form of heating, known as calcination, is suitable for prolonged heating at a temperature above 400° C. For example, for dehydration of some substances, substances are calcined (ignited) until they attain a constant weight. Calcination and dehydration of crystalline substances e.g. calcium chloride, sodium sulphate, copper sulphate and others is usually carried out in porcelain or metal crucibles. The crucible is placed on a clay triangle so that only ⅓ of the crucible remains above the triangle. The porcelain triangle is placed on a ring support and the crucible is heated from below with an intense flame, preferably with a Bunsen burner. A liquid mass is thus formed. When the water is completely evaporated, heating is intensified, and calcination is carried on until dry mass is obtained. The mass is broken up into pieces of the desired size, and while still warm, the latter are put into a jar with a ground-glass stopper, or if such a jar is not available, into one with a rubber stopper.

RULES FOR HEATING AND CALCINING

1. Heating and calcining over an open flame can be carried out only in vessels made of heat-resistant glass, high refractory materials ; porcelain or metal.
2. The burner should be turned off and cooled if the flame has struck back.
3. When the heating element of an electric hot plate burns out, disconnect the hot plate from the supply mains, and only then repair it.
4. Be very careful when working with electric heating equipment.
5. Hot water baths are best for careful heating. When using a hot-water bath, see that it is constantly filled with water.
6. All inflammable substances having a boiling point below 100° C are heated or distilled with the aid of a hot-water bath that has been heated beforehand. During the operation, there should be no open flame nearby.
7. The sand used in sand baths should first be calcined in an exhaust hood until smoke and the odour of burning organic matter is no longer detected.
8. When heating is carried out with any type of bath, the substance inside the vessel should be somewhat below the level of, or of the same level as the heat-transfer agent.
9. No inflammable substances, such as benzene, gasoline, etc. should be kept near the place where heating or calcination is being carried out.
10. Prior to calcination, the equipment used should be checked and properly adjusted.
11. No heatng equipment should be put directly on the laboratory bench.

DISCOVERING FOR YOURSELF

1. Name the heating appliances which use liquid fuels. How do they differ from one another ?
2. What types of gas burners are used in a science laboratory ?
3. How should gas burners be ignited ? Disassemble completely a Bunsen burner and reassemble it. Check whether you have assembled it correctly.
4. What should be done if the flame of a gas burner has struck back ?
5. How should inflammable substances be heated ?
6. What heat-transfer agents for baths do you know ? When are baths used ?
7. What is the correct procedure for using a hot water bath ? How is a hot water bath constructed ?
8. How is sand made ready for use in sand baths ? Carry out the operation.

9. How are crystalline substances, such as calcium chloride, copper sulphate, and sodium sulphate dehydrated ?

5.7 Grinding and Mixing

In a science laboratory, it is often necessary to grind solid substances, and to mix solid and liquid substances. All solid materials submitted to the laboratory for analysis must first be pulverized. To prepare solutions of solid substances, the substances must be previously ground.

Grinding : Equipment for and methods of grinding.

Most commonly used in a science laboratory for grinding solid substances are mortars and pestles made of metal, porcelain and other hard materials.

Metal (cast-iron or bronze) mortars are used for rough grinding. How ever, they can be used only for grinding substances that do not scratch the iron or bronze.

Porcelain or heavy glass mortars are often used for grinding small lumps of substances which are softer than porcelain or heavy glass. Very large pieces of hard substances are first broken into smaller pieces with a hammer. When the pieces are of the size of a walnut, they are ground in a mortar. The substance to be ground is filled to $\frac{1}{4}$, or at most to $\frac{1}{3}$ of the height of the inner walls of the mortar. With light but firm blows of the pestle, break the large pieces into smaller ones. Then grind them with the pestle, doing this carefully so that no particles are thrown out of the mortar. Every now and then, clean the pestle and inner walls of the mortar with a spatula, loosening any particles that may adhere to them, and then continue grinding. Do not press the pestle too strongly against the walls of the mortar, as this will cause the arm to tire quickly and thus prolong the process of grinding.

After the grinding is completed, first clean the pestle holding it over the mortar, and then the walls of the mortar with a porcelain or sometimes a metal spatula. The ground substance is poured into a previously prepared container, such as a jar. The jar should be tightly closed, since fine particles of solid substances readily absorb moisture and gas present in the air (e g., carbon dioxide). Very fine particles of a substance can be obtained by grinding it in a metal mortar. However, metal mortars should not be used if the substance to be ground is harder than the metal of which the mortar is made, or if the substance to be ground reacts chemically with it. Hence, it is not advisable to grind acid, salts, and other such substances in a metal mortar.

When the grinding is completed, the mortar and pestle should immediately be washed and dried (with a towel or filter paper) and put away. If coloured streaks remain inside the mortar after washing it, they can be removed by putting common salt into the mortar and grinding it. If this is inadequate, white sand is put into the mortar and ground until the walls of the mortar are clean.

Mixing : Mixing is an operation which consists in uniting several solids or solid and liquid substances to form a homogeneous mass.

To mix solid substances, they should first be finely ground and the particles should be uniform in size. The greater the fineness and uniformity, the more intimate is the mixing.

Solid substances can be mixed in various ways. The substances to be mixed can be poured onto a square sheet of paper or a piece of plastic material, and then mixed by lifting the four corners of the sheet one after another, so that the substances are turned over and over, until a homogeneous mixture is obtained. Mixing can also be done as follows. Pour into a beaker or a jar of a suitable capacity the substances to be mixed; the total volume of the substances should not exceed $\frac{1}{2}$ the beaker's capacity. Then take another beaker or jar of the same size and carefully pour into it the contents of the first beaker or jar. This process is repeated until a homogeneous mixture is obtained.

Solid substances can be thoroughly mixed by passing them several times through a sieve with openings which are 2-3 times larger in diameter than the particles of these substances.

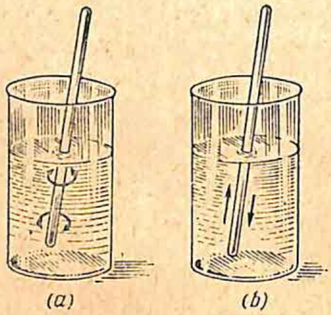

(a) (b)

Fig. 5.19 Stirring Liquids in a beaker with a glass rod :
a) correct way
b) incorrect way

Yet another method of mixing solid substances consists in grinding them together in a mortar. Every now and then, the pestle and the inner walls of the mortar are cleaned with a spatula, loosening any particles that may adhere to them. The process is continued until a homogeneous mixture is obtained. As a rule, all equipment for grinding solid substances can be used for mixing them as well. Liquids are mixed by hand, by machanical means, or by blowing gas through the liquid mixture. The simplest way is to mix the liquid in a beaker with the aid of a glass rod as shown in Fig. 5.19. Cylinders are sometimes used for mixing liquids. The liquids to be mixed should not occupy more than $\frac{3}{4}$ the capacity of the cylinder. Proceed as follows. Close the cylinder with a stopper, then shake it, with one hand pressing on the stopper and the other holding the bottom of the cylinder. The same procedure is used for dissolving solid substances in a liquid.

DISCOVERING FOR YOURSELF

1. How much of a substance to be ground should be put into a mortar? What should be taken into consideration in this case?
2. What is the correct way of grinding with a pestle?
3. What should be done with large lumps of a solid substance before they are ground in a mortar?
4. What measures must be taken when grinding dust-producing substances, or substances harmful to the health? Can the grinding of these substances be done on a laboratory bench? Why?
5. What kind of mortars are used for grinding hard substances?
6. Can a substance be ground in a given mortar if the substance is harder than the material of which the mortar is made? What would happen in this case?
7. How does an agate mortar differ from a porcelain mortar? Why is the hardness of the material of which a mortar is made important?
8. Pour some crystalline salt into a procelain mortar and grind it.
9. How should a mortar be cleaned after it has been used?

Govt. of West Bengal

5.6 Filtration

General Principles

Filtration is the separation of solids from liquids by passing the mixture through a porous material. The pores or openings of this material are so small that they retain the solid particles on the surface of the material, allowing the liquid to pass through it. The material used for retaining the solid particles is called a filter, the liquid passing through the filter, the filtrate; and the solid material remaining on the filter (say, filter paper in a funnel), the residue.

The rate of filtration is the amount of liquid that passes through a given area per minute. It depends on the viscosity of the liquid, on the temperature and pressure, the size and the nature of the solid particles to be separated, and on the porosity and thickness of the filtering surface. Liquids of low viscosity pass through a filter more readily than liquids of high viscosity. Hence, the rate of filtration increases with a decrease in the viscosity of a liquid. Since the viscosity decreases with an increase in temperature, solutions are often first heated and then filtered while it is hot.

The rate of filtration also depends on the porosity and thickness of the filtering surface and on the nature of the filtering material. The larger the pores, the more readily a liquid passes through the filter, and vice versa. To facilitate the process, filtration is often carried out by creating a reduced pressure in the receiving container.

Filtering Materials

Various porous materials, such as filter paper, cotton wool, cloth, porous plates of glass or porcelain, finely divided charcoal, etc. can serve as filters. The material most commonly used in laboratory is filter paper.

Filter paper used in laboratory usually comes in packages and is in the form of circles of various sizes.

Methods of Filtration

There are various types of filtration. The choice of method of filtration depends on the nature of the liquids to be filtered and on the properties of the precipitate to be separated.

Filtration at room temperature and atmospheric pressure

The funnel is put into a ring which is fastened to a stand; under the funnel is placed a beaker for the filtrate. The stem of the funnel should be below the rim of the beaker, and it should touch the walls of the beaker (fig. 5.20)). In the funnel is put the filtering material, such as filter paper, cotton, wool, etc. If the circles of filter paper are not available, filters can be made from the sheet of filter paper. To make an ordinary filter (fig. 5.21), a square sheet of filter paper (A) is folded in half twice (B,C.). The ends of the filter are then cut neatly by scissors, as shown by the broken line in fig 5.21 (D). The filter is finally opened up into a cone (E). To make a folded filter, at first follow the same procedure (A-D); then unfold the filter (F) and fold each segment in half twice towards each other (G-I); now turn the filter over (J) and, after it has been folded twice

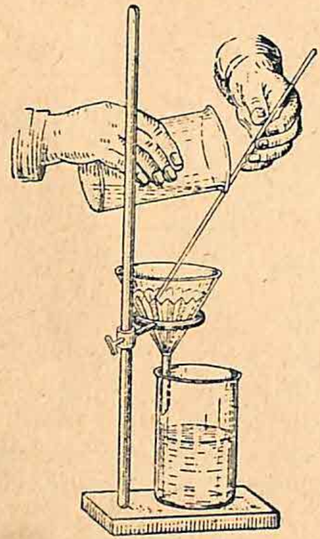


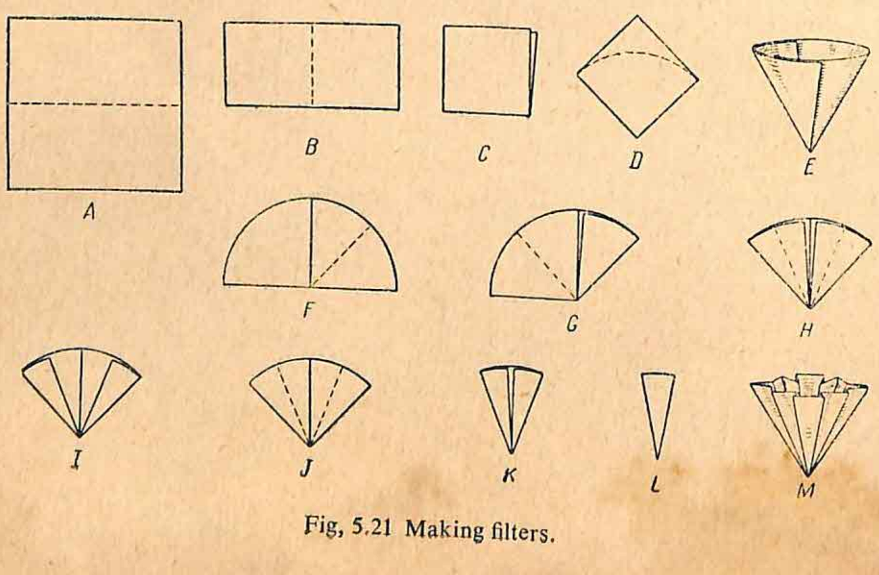
Fig. 5.20 Correct way of pouring liquid into a filter.

more (K-L); it may be opened up to assume its final shape (M). In this case it is more convenient to trim the ends after folding.

When the filter is properly put into the funnel, wet it with distilled water.

First allow the precipitate to settle down (in the beaker) and then carefully without disturbing it, pour the liquid into the funnel. This can be done with the aid of a glass stirring rod. Hold the rod at a point which is about 6-7 cm. from the end against the rim of the beaker containing the liquid and solid to be filtered and pour the liquid down the rod, guiding the stream not to the centre but to the side of the filter as shown in Fig. 5.20. Otherwise the filter paper may tear.

The level of the liquid in the filter should be below the edge of the filter paper by at least 5-10 mm. The filter should never be overfilled with the precipitate; the level of the precipitate should be at least 10 mm below the edge of the filter paper. In some experiments the residue obtained after filtration requires washing. The purpose of washing is to remove impurities from the precipitate and to have the residue in the purest state possible. This is done by dissolving the impurities in it with water or with a wash liquid.



Fig, 5.21 Making filters.

A precipitate should be filtered and washed shortly after it is obtained. Pour a little water (about 3 ml) over the residue and repeat twice again. Take out the filter paper, open it out and dry it. In most cases the precipitates should not be left overnight to be filtered and washed the next day.

Filtration under reduced pressure: When rapid filtration is necessary or when filtration proceeds with difficulty at atmospheric pressure, filtration can be carried out under reduced pressure. For this purpose assemble an apparatus (Fig. 5.22) consisting of a porcelain Buchner funnel, a suction flask, a safety trap and a water-jet pump.

The Buchner funnel is inserted into a one-hole rubber stopper. The suction flask is connected through thick-walled rubber tubing to the trap which is connected to the vacuum pump. The safety trap should always be used, since it prevents the possibility of the water from the water-jet pump getting into the suction flask. If water begins to enter the trap, the flask is disconnected from it, and connected again only after all the water from the trap has been sucked off.

Place on the perforated bottom of the Buchner funnel two filter paper circles of the appropriate size. If no filter circles are available, they can be cut out as follows. Put a piece of filter paper on top of the funnel, press it lightly with the palm to get an impression of the funnel edge, then cut out the circle with a pair of scissors, and trim it to fit the perforated bottom of the funnel. The first circle of filter paper should completely cover the perforated bottom of the funnel (1-2 mm from the walls of the funnel). The diameter of the second circle should 3-4 mm. greater than the first one.

To start filtration, turn on the water-jet pump, and then moisten the filter paper with distilled water. When the filter paper is sucked tightly to the bottom of the funnel, pour the solution into the funnel. First pour the greater part of the liquid into the filter, than shake the remaining liquid and precipitate and pour it into the funnel. When a Buchner funnel is used, the precipitate must not overfill the funnel. The level of the filtrate inside the suction flask should be below the side tube which connects the suction flask to the trap. When a large amount of filtrate is collected, the filtration process is stopped, the suction flask disconnected from the trap, and the filtrate is either poured out into the sink or kept if necessary. Then the flask is again connected to the trap and filtration is continued.

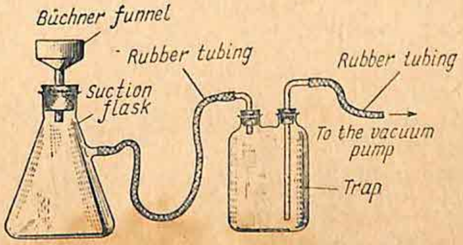


Fig. 5.22 Apparatus for filtration under reduced pressure.

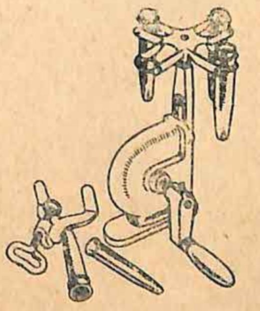


Fig. 5.23 Hand-driven centrifuge

Fig. 5.24 Centrifuge tube

After filtration is completed, the funnel is removed from the flask, inverted and given a few light taps until the filter with the residue on it falls onto a clean piece of paper prepared before hand. The residue is loosened with a spatula if necessary, and left on the paper to dry.

In some cases, instead of a Buchner funnel, an ordinary funnel in which a perforated porcelain plate has been placed can be used. For such a funnel, filter paper circles are cut out and placed as described above for the Buchner funnel.

Centrifugal Separation

Solid particles can be separated from a liquid not only by filtration but also by other methods. In some cases filtration is replaced by centrifugation, especially when working with small amounts of solutions. For this purpose is used the hand-driven centrifuge with four tube cases (fig. 5.23). The use of centrifuge is based on the utilisation of centrifugal force. During rotation at very high speeds the solid particles, which are suspended in the liquid and which have a greater density than the liquid, are thrown from the centre by the centrifugal force and collect at the bottom of the vessel. The main component of the hand-driven centrifuge is a vertical rotating axis perpendicular to which at the upper part is a bar with metal tube cases attached to it. Into these cases are put centrifuge tubes with tapered tips (fig. 5.24), containing the liquid from which suspended particles have to be removed. The tubes in a centrifuge are arranged in pairs and symmetrically opposite to each other. During the centrifugation the tubes must be balanced, it is important that the tubes have identical mass.

DISCOVERING FOR YOURSELF

1. Define the term *filtration*.
2. What is a filter? What kinds of filters are used?
3. Define the term filtrate.
4. Define the term residue.
5. What are the conditions that facilitate filtration? Why?
6. Name the methods of filtration that you know.
7. Assemble an apparatus for filtration at room temperature and atmospheric pressure. What equipment does one need for this?
8. How should an ordinary and a fluted fiter be folded? Make both filters.
9. How should a filter be fitted into a funnel? Is it permissible to have the edge of the filter protrude over the edge of the funnel? Why? Fit into a funnel an ordinary and a fluted filter.
10. Assemble an apparatus for filtration under reduced pressure. What equipment does one need to do this? What is the purpose of each piece of equipment?
11. Why is it necessary to have a trap (Woulf's bottle) between the water-jet pump and the suction flask? Can vacuum filtration be carried out without it?
12. What conditions must be observed during centrifuging? Why is it necessary that the centrifuge tubes have an identical mass? How should they be positioned inside a centrifuge?

5.7 Distillation and Sublimation

General principles

When a liquid is heated its temperature rises and the vapour pressure increases until it becomes equal to the external pressure (atmospheric pressure). The temperature reached at this point is known as the boiling point of the liquid i.e., at this temperature the liquid begins to boil. The boiling point of a liquid depends on many factors, and is most strongly affected by the atmospheric pressure. With a decrease in atmospheric pressure, the boiling point of a liquid also decreases. For example, the boiling point of water at the standard pressure of 760 mm Hg is 100°C; if the pressure drops to 200 mm Hg, the boiling point will be well below 100°C. On the other hand, an increase in pressure will result in a rise in the boiling point of a liquid, e.g., at a pressure of 2 atm, the boiling point of water is 120.6°C. If the vapours of a liquid are cooled, they are condensed and the liquid is thus regenerated. Such a liquid is called a distillate or a condensate. Many mixtures can be separated into their components by means of distillation because the components boil at different temperatures.

Distillation

Distillation is one of the means of obtaining chemically pure substances by freeing them from impurities. There are three types of distillation: distillation under atmospheric pressure, distillation under reduced pressure (vacuum distillation) and steam distillation.

Distillation under atmospheric pressure: Such distillation is carried out only if the liquid to be distilled can be heated without becoming decomposed, i.e., if it is thermally stable at its boiling point under the said conditions. An apparatus for distillation under atmospheric pressure is shown in fig. 5.25. It consists of a Wurtz flask, a Liebig condenser, a receiver, and a thermometer suitable for the given temperature range.

The Wurtz flask is fitted with a rubber or cork stopper (depending on the liquid to be distilled) in the centre of which a hole is bored for a thermometer. The mercury bulb of the thermometer should be opposite the vapour outlet tube or somewhat below it and should not touch the walls. Then a stopper is selected for the condenser tube, and a hole bored in it for the vapour outlet tube of the Wurtz flask. The vapour tube should extend into the condenser tube not less than 5-6 cm, almost approaching its narrow part. The receiver for the distillate can be a conical flask, beaker, or other vessel. Sometimes, especially in distillation of organic liquids having a low boiling point, the end of the condenser tube is fitted with a stopper carrying an adapter whose narrow end is placed inside the receiver; the condenser tube should extend into the adapter at least 5 cm. In some instances the receiver is also fitted with a stopper in which a hole is bored for the narrow end of the adapter.

All the parts of the distillation apparatus should be thoroughly washed and dried before they are assembled. Then the Wurtz flask is fastened to a stand; another stand with a large clamp is used for holding the condenser. After the vapour outlet tube from the Wurtz flask is securely connected to the condenser tube, water is allowed to

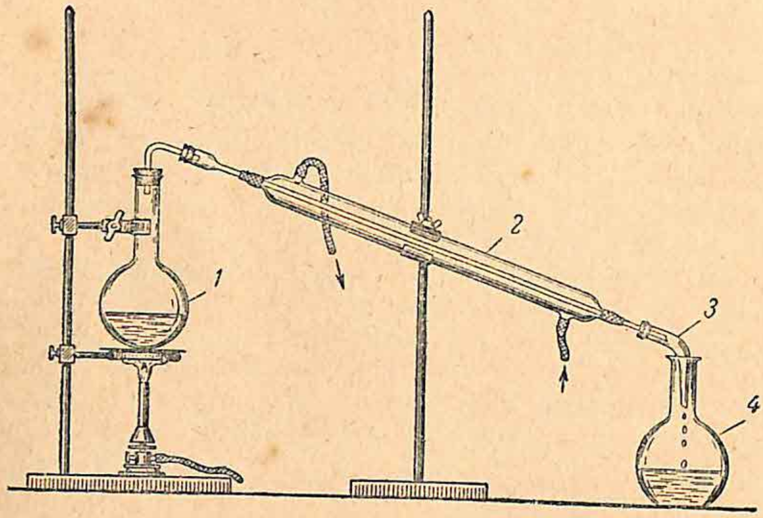


Fig. 5.25 Distilation of water
1—round-bottom flask; 2—condenser; 3—adapter; 4—receiver.

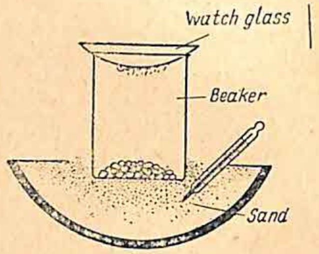


Fig. 5.26 Apparatus for sublimation.

enter the condenser through the inlet next to the receiver and to flow out through the outlet at the other end. The Wurtz flask is usually heated with a hot water bath and seldom with the open flame of a burner.

After the Wurtz flask is fastened to the stand, the stopper with the thermometer in it is pulled out and in its place is inserted a long-stem funnel; the tip of the stem should be below the vapour outlet tube. The liquid to be distilled is poured through the funnel into the flask. The amount of liquid poured in should not exceed two-thirds of the capacity of the flask. Thus, for example, not more than 300 ml. of the liquid to be distilled should be poured into a 500 ml flask. To prevent the possibility of sudden boiling up of the liquid during distillation, which could cause the liquid to go into the condenser, boiling chips (capillary tubes sealed at one end, pieces of pumice stone, or glass wool) are put into the flask. The flask is then closed with the stopper with the thermometer in it. Only after making sure that the condenser is securely connected to the flask and that the water admission is in order, water is allowed to flow gradually into the jacket of the condenser and then distillation is started.

The distillation apparatus must be assembled correctly and neatly. If a wire gauze with an asbetos centre is used in heating, the flask should rest on the gauze placed on a ring support. When distilling inflammable substances, a hot water (or some other) bath is used to avoid an open flame. When distillation is completed, first heating is stopped and a few minutes later, the water inflow into the condenser is discontinued. The apparatus is allowed to cool so that it can be touched with the hand. Then the receiver is removed and after that the stopper with the thermometer is removed, cleaned, and put away. The apparatus is carefully disassembled. Any residue that may remain inside the distillation flask is poured out into the sink.

Sublimation

When heated, most solid substances can be transformed into liquids which boil at a certain temperature. The vapours of such a solid substance form, on condensing, a liquid which, on cooling, becomes sodified. There are, however, some substances which can pass directly into the vapour state without the intermediate formation of the liquid phase. This process is called sublimation. Substances that readily can be sublimed are: iodine, naphthalene, some salts of ammonia, and various organic substances. The apparatus used for sublimation is shown in Fig. 5.26. The simplest sublimation apparatus consists of a beaker covered with a watch glass which is filled with cold water or pieces of ice. The solid substance to be purified is placed in the beaker which is heated in a sand bath. During the heating the solid substance undergoes sublimation and the sublimed crystals collect on the cooled surface of the watch glass. At the end of the operation the sublimate is scraped off with a glass rod. To obtain a still purer sublimate it can be resublimed several times. More complicated sublimation apparatus have a built-in-condenser and heat source.

Rules for Distilling

1. All glassware used for distillation should be thoroughly washed prior to assembling the distillation apparatus.
2. The stoppers used should be made of such materials that are not affected by the liquid to be distilled.
3. The mercury bulb of the thermometer inserted in the neck of the Wurtz flask should be in the centre of the neck and opposite to or just below the vapour outlet tube.
4. Water should fill the entire water jacket of the condenser and start flowing through it before the distillation flask is heated.
5. Capillary tubes, pieces of pumice stone, or the like should be placed into the distillation flask.
6. Great care should be taken when distilling inflammable liquids.

DISCOVERING FOR YOURSELF

1. On what property of liquids is the principle of distillation based?
2. How does external pressure affect the boiling point of a liquid?
3. Make a schematic drawing of the apparatus for distillation under atmospheric pressure.
4. What purpose do boiling chips serve?
5. What is the correct procedure for disassembling a distillation apparatus?
6. Define the term sublimation. What is the difference between distillation and sublimation?

5.8 Drying

Drying consists in the removal of water or its vapours from a substance and obtaining this substance in the dry form. Depending on the nature of the substance and its moisture content, drying can be carried out in different ways. Substances that can be dried include crystalline and amorphous solids, organic and inorganic liquids, and gases. In a broader sense, drying may consist not only in the removal of water or its vapours but also of organic solvents or their vapours.

Drying of Gases

Gases are dried by passing them through: (1) solid absorbents (e.g., hygroscopic substances) for absorbing water vapours, or adsorbents (absorbents) which adsorb or absorb not only water vapours but also vapours of organic substances, or (2) liquid absorbents which absorb water vapours and vapours of organic substances.

It is essential that the absorbent be inert with respect to the gas to be dried. To remove impurities which may be present in a gas, scrubbers are used if the absorbent is a liquid; or absorpotion columns (Fig. 5.27) if the adsorbent or absorbent is a solid substance. The scrubbing bottles are filled with the absorbing liquid to not more than $\frac{1}{4}$ their height. Very often several scrubbers are connected in a series. This prolongs the time during which the gas passes through the scrubbers and increases the contact area between the gas and the absorbents, thus permitting more efficient removal of water vapours or vapours of an organic solvent from the gas.

Below are given the drying agents commonly employed in chemical laboratories for drying gases.

Gas	Drying agent
Oxygen (O_2)	Concentrated H_2SO_4, P_2O_5
Hydrogen (H_2)	Concentrated H_2SO_4
Nitrogen (N_2)	Concentrated H_2SO_4
Carbon dioxide (CO_2)	Concentrated H_2SO_4, P_2O_5
Chlorine (Cl_2)	Concentrated H_2SO_4, $CaCl_2$
Hydrogen chloride (HCl)	Concentrated H_2SO_4
Hydrogen sulphide (H_2S)	P_2O_5, $CaCl_2$
Sulphur dioxide (SO_2)	Concentrated H_2SO_4

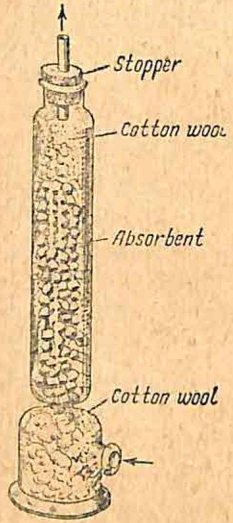


Fig. 5.27 Absorption column.

Aluminium oxide, silica gel and similar substances are often used as adsorbents. The calcium chloride tubes and absorption columns, used for drying air, are usually filled with granulated (not powdered) calcium chloride, or magnesium perchlorate which is the most efficient agent for absorbing water vapours. To free air from carbon dioxide, it is best to use ascarite (an asbestos material), which is more convenient to use than solid alkalis.

The choice of the drying agent largely depends on the properties of the gas to be dried.

Drying of Solids

Solid substances can be dried in different ways, depending on their properties.

Air-drying at room temperature

Nonhygroscopic substances that have been recrystallized are usually dried in this way. The moist substance is spread in a thin layer on a piece of clean filter paper and loosened with a porcelain spatula. It is then covered with another piece of clean filter paper and left to dry for a long period of time. An electric fan can be used to accelerate the drying process by blowing air over the substance being dried. The stream of air should be directed above the layer of the substance and parallel to it. During the drying, the substance should be periodically turned with a porcelain spatula. Care should be taken to prevent dust from getting onto the substance. The dried substance is poured into a clean container which is then tightly closed.

Drying with heating under atmospheric pressure

This can be done in evaporating dishes (also on pans or trays) or in drying cabinets.

When an evaporating dish is used, it is heated in a bath (hot-water bath, sand bath, etc.). The dish should not be heated with an open flame, since this may cause local overheating and decomposition of the substance. It is more convenient and less dangerous to dry solids in a drying cabinet. In science laboratories, extensively used are electric drying cabinets with or without a thermoregulator. The thermoregulator makes it possible to dry a substance at a constant given temperature which is usually maintained within ± 2 to 5°C. The temperature of such cabinets can be varied from 50 to 220°C. The substance to be dried is put into a suitable container (beaker or watch glass) or is simply spread on a sheet of paper and is then placed on the upper shelf of the cabinet.

The duration of drying varies depending on the temperature of drying.

The most commonly used electric drying cabinets must be connected to the power-supply line for which they are designed. Drying cabinets are also used for drying glassware, which is put inside the cabinet on a piece of clean filter paper.

Drying under reduced pressure

Many substances, when heated under ordinary conditions, decompose or undergo changes in composition. It is impossible to remove water from such substances by means of ordinary heating techniques. The drying temperature must be lowered and this can be done only by reducing the pressure. For this purpose vacuum drying cabinets are used, which make it possible to dry substances at relatively low temperatures under reduced pressure. Under a sufficiently reduced pressure water can even be removed from a substance at room temperature, thus avoiding possible decomposition of the substance. The substance to be dried is spread in a thin layer on the bottom of a flat container, which is then put into the vacuum drying cabinet.

The vacuum drying cabinet is equipped with a manometer and thermometer. The door is fitted with a rubber gasket for tightness and is locked with the aid of bolts. There is a sight hole in the door for observing the drying process. The drying cabinet is connected to a vacuum pump. After the desired reduction in pressure is achieved, the valve connecting the cabinet to the vacuum pump is closed. If necessary, heat is turned on, which is controlled by a thermoregulator. After drying, air is slowly let into the drying cabinet. When the pressure inside and outside the cabinet is the same, the door of the cabinet can be opened and the substance taken out.

Drying in a Desiccator

Substances that cannot be heated can also be dried in a desiccator filled with a water-absorbing substance. This method of drying is the safest of all, but is time-consuming, and is usually carried out at room temperature. There are also electrically heated desiccators with temperature control.

Drying with infrared rays is the quickest way of drying. The temperature is regulated by adjusting the distance between the lamp and the substance to be dried which is put in a flat-bottomed container.

The substance to be dried is spread in as thin a layer as possible on the bottom of the container which is placed under the reflector. The temperature of the illuminated area is measured with a thermometer and is adjusted by raising or lowering the reflector and lamp.

DISCOVERING FOR YOURSELF

1. Define the term drying.
2. What is meant by drying in the broad sense of the word?
3. How are gases dried? What apparatus is used for this purpose?
4. To what level of the scrubber should the water-absorbing liquid be poured?
5. What substances can be used for drying gases?
6. Can the same water-absorbing substance be used for drying different gases?
7. How are solid substances dried? What techniques are used for this purpose in science laboratories?
8. When must drying be done under reduced pressure? What substances should be dried by this method?
9. What is the difference between a vacuum drying cabinet and an ordinary drying cabinet?
10. When is a desiccator used for drying? What drying agents are used in this case?

5.9 Evaporation and Recrystallization

General Principles

To separate a substance from a solvent it is necessary to remove the solvent completely; to concentrate a solution calls for only partial removal of the solvent. The process by which the solvent is completely removed from a solution, whereby the dissolved substance is separated, is know as evaporation. The partial removal of a solvent resulting in the concentration of the solution is known as concentration by evaporation. Both of these operations are carried out at temperatures below the boiling points in porcelain, glass, or enamelled evaporating dishes.

Depending on the nature of the solvent, evaporation is carried out by heating the solution in an evaporating dish either with an open gas flame, in a hot-water bath or on an electric hot plate.

Although the majority of inorganic substances are stable at relatively high temperatures, their evaporation or concentration is also usually carried out in a hot-water bath which makes it possible to conduct evaporation with greater care.

Evaporation

When carrying out this operation with the use of a hot-water bath, the evaporating dish should be placed in a ring of the bath, so that at least $\frac{3}{4}$ of its height is immersed in the water. The liquid to be evaporated or concentrated is then poured into the dish to not more than 2/3 of the height of the dish. If the upper part of the dish is not hot enough, crystals from the solution will 'climb up' the walls of the dish. To avoid this the level of the liquid inside the dish should be below the water level. During evaporation the contents are stirred from time to time and the solid crust that forms on the top of the liquid is broken up.

When evaporating an aqueous solution, the hot-water bath is heated with a gas burner or on an electric hot plate, taking care that the bath is always filled with water.

If the solution to be evaporated is very dilute, it is first concentrated to $\frac{1}{4}$ of its volume by distillation and then evaporated. The apparatus used for distillation for this purpose has been described above. After the solution has been evaporated to dryness or to the desired concentration, heating is stopped, the dish removed from the bath, and its outer surface dried with a towel. The residue formed is scraped off with a spatula into a suitable container.

Concentration by Evaporation

Before starting this operation, it is necessary to calculate the amount of solvent that must be removed to obtain the desired concentration. The completion of concentration can be determined by measuring the specific gravity of the solution.

Recrystallization

Recrystallization is another way of separating and purifying substances. The recrystallization process is based on the dependence of the solubility of a substance on temperature. For many crystalline substances, their solubility increases with an increase in temperature and decreases with a decrease in temperature, the temperature at which a saturated solution is formed being different for different substances. This makes it possible by cooling hot solutions, to separate substances by their fractional precipitation. This is called fractional recrystallization. During recrystallization the size of the crystals formed depends on the rate of cooling of the saturated solution. Rapid cooling yields a fine precipitate; slow cooling gives larger crystals.

The substance to be recrystallized is dissolved in water with the aim of obtaining a saturated solution at a temperature to which it may be heated. First, the solvent is heated in a bath; into the hot solvent the crystalline substance is added in small portions until it stops dissolving in the solvent. The solution is then heated additionally for a short time, and filtered into a crystallizing dish immersed in ice or cold water. On being cooled, fine crystals start falling out of the solution. They can be filtered off on a Buchner funnel or simply by decanting the mother liquor (i.e., the liquid from which the crystals are formed). The crystals are pressed and dried by using plates made of refractory clay.

Nonhygroscopic substances, after filtration on a Buchner funnel under suction, are poured onto a clean piece of filter paper and air-dried. Hygroscopic and unstable substances should not be dried in this manner. After filtration, they are transferred to a suitable container prepared beforehand and dried in a desiccator.

As mentioned earlier, rapid cooling yields fine crystals. Fine crystals can be more readily separated from the mother liquor than large crystals, and therefore from fine crystals a purer product can be obtained. The mother liquor contains a small amount of the crystallized substance and some impurities. If cooling is carried out slowly (for example, if the saturated solution is air-cooled), the crystals grow in size, and after a long period may grow into very large crystals. Such crystals are less convenient to work with, and they are less pure than fine crystals.

The mother liquors should not be discarded after crystallization. If they are concentrated by evaporation, filtered and cooled, an additional crop of crystals can be obtained. However, it should not be mixed with the first crop since they are less pure. To obtain a very pure substance that is practically free of impurities, the recrystallization process is repeated several times. Of course, after each operation the amount of the product will decrease since some of it will always remain in the mother liquor.

The cooling agent can be cold water, ice, ice mixed with common salt, ice with calcium chloride, etc. Often the flask containing the solution to be cooled is put under a stream of tap water. In this case the flask is slowly rotated so that the cold water runs over the entire outer surface of the flask. From time to time the contents are stirred by shaking the flask. It should be remembered that the filter used in filtering hot solutions retains some of the recrystallized substance. Hence, when filtration is over, the filter should be rinsed with very small portions of the hot solvent.

DISCOVERING FOR YOURSELF

1. What is the difference between evaporation and concentration by evaporation?
2. When is evaporation carried out under reduced pressure?
3. Describe the procedure for carrying out evaporation. What apparatus is used for these operations?
4. How much of a liquid should be poured into an evaporating dish? Should the evaporating dish be filled with a solution to its rim?
5. How and with what equipment should evaporating dishes be heated when carrying out evaporation?
6. To what depth should the evaporating dish be immersed in a hot-water bath?
7. How is "climbing up" of the precipitate during evaporation avoided?
8. On what properties of substances is the process of recrystallization based?
9. Why is there a decrease in the amount of the crystallizate after each recrystallization?
10. What should be the size of the crystals if it is required to obtain a very pure substance? Why?
11. What cooling agents are used for cooling hot saturated solutions?
12. Define the term mother liquor.
13. How can an additional crop of crystals be obtained from a mother liquor ?

5.10 Determination of Density and Specific Gravity

One of the most important characteristics of a substance is its density (the mass of unit volume of the substance) which is usually designated by the Greek letter δ. Any impurities present in a substance affect its density. The purity of a substance, therefore, can be judged by its density. In science laboratory it is often necessary to determine the density of solutions of liquids. The concentration of a solution can be found by determining its density. For example, the concentration of solutions of salts or alkalis and many acids can be determined from their density. Tables in handbooks give the densities of solutions of certain substances corresponding to different concentrations of the substance in the solution. Thus, for example, in a table it can be found that 100 g of sulphuric acid of a density of 1.835 g/cm^3 contain 95.72 g of pure sulphuric acid; a sodium hydroxide solution whose density is 1.430 g/cm^3 contains 40 per cent by weight of sodium hydroxide (i.e. 100 g of this solution contain 40 g of dissolved sodium hydroxide).

Very often the specific gravity (sp.gr.) of a substance is determined i.e. the ratio of the density of the substance to that of water at a specified temperature (density of water equal to 1). The specific gravity of a substance varies with temperature. Usually with an increase in temperature, the specific gravity decreases, and vice versa.

The specific gravity of a substance is determined by means of: hydrometers (ordinary or special ones) and pycnometers. There are many ways of determining the specific gravity of a substance, but the two mentioned above are the most important and most commonly used.

Determination of Specific Gravity with Hydrometers

A hydrometer consists of a glass tube (stem) with a bulb at the bottom filled with lead shot, mercury, or some other substance. Inside the tube there is a calibrated scale indicating the specific gravity. Sometimes the hydrometer is provided with a thermometer which makes it possible to observe the temperature at which the specific gravity of a substance is measured. As said above, the specific gravity of a substance depends on the temperature at which it is determined. If the specific gravity is not measured at the standard temperature[1], the reading obtained should be corrected accordingly.

To measure the specific gravity of a liquid with a hydrometer, the liquid is first brought to the standard temperature by keeping it in a thermostat, if possible, and then poured into an ungraduated cylinder whose capacity is not less than 0.5 litre. After the temperature of the liquid is checked, the hydrometer is carefully lowered into the liquid and held there by the hand until it floats. The hydrometer should be in the centre of the cylinder and should not touch the walls (Fig. 5.28). After the hydrometer has come to a standstill, the reading on the scale is taken. The division opposite the upper part of the meniscus of the liquid is the specific gravity of the liquid. Once again the temperature is checked, and the hydrometer is removed from the liquid, rinsed with water, carefully dried and put in its case. If necessary, the obtained reading is corrected to the standard temperature.

On hydrometers used for liquids whose specific gravity is less than that of water, the

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[1] In many countries 20°C is taken as the standard temperature.

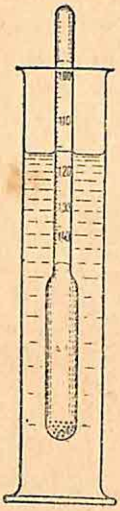

Fig. 5.28 Determining density of a liquid by a hydrometer

maximum reading of the specific gravity on the scale is 1.000 and is located at the bottom of the scale. The lowest reading is located at the top of the scale. On hydrometers for liquids whose specific gravity is greater than that of water, the lowest reading on the scale (1.000) is located at the upper end of the scale. In all cases the more deeply a hydrometer sinks into the liquid, the lower is the specific gravity of the liquid.

In Science laboratories there are sets of hydrometers for measuring specific gravity within different ranges, for example: 1000-1200°, 1200-1400°, 1400-1600°, etc. Hydrometers are fragile and should be handled very carefully. If it has no suitable case, the hydrometer should be put in a drawer lined with cotton. Sets of hydrometers are sometimes stored in wooden boxes with a separate recess for each hydrometer.

Determination of Specific Gravity with Pycnometers

To determine the specific gravity of a liquid with greater precision, pycnometers are used. Pycnometers are small glass vessels of various forms, and of accurately defined volumes. Some pycnometers are equipped with a thermometer. Before use, the pycnometer is thoroughly washed and dried, and then weighed on an analytical balance to the nearest 0.0002 g. After this it is filled with distilled water to the mark on the neck, and placed in a thermostat maintained at the standard temperature (20°C) for not less than 30 minutes. After the pycnometer is taken out of the thermostat, it is wiped on the outside and weighed on the same analytical balance. The water is poured out, the pycnometer is dried, and then filled with the liquid whose specific gravity is to be measured. The pycnometer is again placed in the thermostat for the same period of time, then taken out and wiped on the outside and weighed.

The specific gravity is calculated from the following formula:

$$\text{Sp gr} = \frac{P_2 - P}{P_1 - P}$$

where P = mass of the empty pycnometer, g

P_1 = mass of the pycnometer filled with water, g.

P_2 = mass of the pycnometer filled with the liquid whose specific gravity is being measured, g.

The differences (P_2-P) and (P_1-P) are the mass of the liquid and water in the pycnometer, respectively. If the measurement is not made at the standard temperature it is necessary to correct the results to normal temperature.

DISCOVERING FOR YOURSELF

1. Why is it important to determine the specific gravity of a substance? What can be found out about a substance from its specific gravity?
2. How does specific gravity vary with temperature?
3. What methods of measuring specific gravity do you know?
4. Describe the construction and working principle of the hydrometer and how it is used in measuring the specific gravity of a substance.
5. How should a hydrometer be lowered into a cylinder when measuring the specific gravity of a substance?
6. What types of hydrometers are used in science laboratories? How do they differ from one another?
7. How is specific gravity measured with the aid of a pycnometer?
8. Write the formula for calculating the specific gravity with the aid of a pycnometer.

5.11 Meaurement of Temperature

In laboratory work, measurement of temperature is a frequent operation. Many processes take place only at a certain temperature. The purity of a substance can also be judged by its boiling point (in the case of liquids) or its melting point (in the case of solids).

Methods and Instruments for Measuring Temperature

For measuring temperature, thermometers of various constructions and designed for various purposes are used.

The most commonly used in science laboratories are liquid-filled thermometers (mercury or alcohol), especially those filled with mercury. There are two types: the tubular and the rod-like thermometers. The former is made of a glass tube (the stem) with a bulb at the bottom communicating with a capillary tube. The bulb is filled with mercury.

Inside the stem there is usually a porcelain scale, calibrated in celsius or fahrenheit degrees, to which the capillary tube is attached. The rod-like thermometer is made of thick-walled glass tubing with a capillary bore ending in a bulb filled with mercury. The scale is engraved on the outside the glass tube. As temperature rises and falls, the mercury expands and contracts, the position of the end of the mercury thread indicating the temperature. Thermometers must be handled very carefully. They are kept in suitable cases, or in a drawer lined with cotton or other soft material.

In the case when the thermometers have a scale on the outside, the colour of the graduation marks may fade with time. The scale can be restored by rubbing the surface with burnt cork or graphite powder. For better adhesion of graphite, the scale should be first rubbed with a 5-10 per cent alcoholic solution of rosin.

For Science Laboratory supplies thermometers are designed for measuring temperatures down to 0°C and up to 110 and 360°C. Besides the laboratory thermometers, there are special thermometers, such as clinical thermometer designed for measuring temperature down to 95°C and up to 110°C.

Liquid-filled thermometers should not be heated above the highest temperature for which they are designed lest they break or become unfit for use. When a thermometer is cooled suddenly or not handled with care, the mercury thread may break up into sections. Such thermometers should not be used. An attempt can be made to obtain a continuous thread once more by shaking the thermometer or heating it to slightly below the highest temperature for which it is designed.

After use, a thermometer should be allowed to gradually cool down to room temperature; then it is wiped clean and properly stored. By no means should a dirty thermometer be left unwiped. To measure temperature, the thermometer is inserted into the medium whose temperature is to be measured; it should not touch the bottom or the walls of the container. The bulb and part of the stem of the thermometer must be immersed in the liquid. If the thermometer is installed in an apparatus it should not touch the walls of, or any part of the apparatus.

Rules for using Thermometer

1. Before using a thermometer, make sure to check for what temperature range it is designed.
2. A thermometer should not be heated above the temperature for which it is designed.
3. A thermometer should not be heated too long up its limiting temperature.
4. When measuring the temperature of a liquid the thermometer should be immersed in the medium, taking care that the mercury bulb does not touch the walls of the container.
5. Readings on a thermometer should be taken without removing it from the substance whose temperature is being measured.
6. After use the thermometer should be allowed to gradually cool down to room temperature; then it is cleaned, inserted in its case, and put in a place.
7. Thermometers should be handled with great care. It is especially dangerous if the mercury from a broken thermometer is spilled onto the floor and gets into places from which it cannot be removed, since mercury vapours are poisonous.
8. When not in use thermometers are kept in suitable cases or in drawer lined with cotton or other soft material.

5.12 Gas Collecting Techniques

The gas collection technique depends on the properties of a particular gas.

Air Displacement Techniques

A test tube in which gas is prepared is fixed on a stand. The end of the delivery tube is lowered into the receptacle almost to the bottom level. If the density of the gas is about that of air, or somewhat greater, it is collected in an open test tube placed in the upright position (Fig. 5.29). If the gas is lighter than air the test tube should be placed with its mouth downwards (Fig. 5.30).

Collecting gas over water

A pneumatic trough is required to collect gas over water. A small crystallization basin or an evaporating dish, etc. can be used for the purpose. The test tube intended to collect gas is filled with water, its mouth is closed with a finger tip, turned upside down, and lowered into the basin filled with water.

The test tube is opened carefully under water and fixed in the basin so that the water does not pour out of it. When all the air is displaced from the reaction vessel by the evolved gas, the end of the delivery tube is immersed into water in the basin and is put into the mouth of the tube as shown in (Fig. 5.31). When the test tube is filled with gas, its mouth is closed with a finger tip or a stopper, and the test tube is removed from the basin. If the gas is prepared with heating, the end of the delivery tube should be removed from the basin as soon as the receptacle is filled with the gas, since as the apparatus is cooled, water may be sucked into it from the basin.

If the object of the laboratory work is only to observe the evolution of gas, to establish its colour and odour, or to observe its combustion, the gas need not be collected. The colour of the gas can be easily established by observing through the glass of the test tube, and its odour smelt by wafting it toward the nose. The apparatus shown in fig. 5.32 is used to illustrate the evolution and also the absorption of gas by a liquid.

If the gas is tested for combustibility, the jet of the gas issuing from the delivery tube is ignited (Fig. 5.33). While doing so remember the following : if the gas forms an

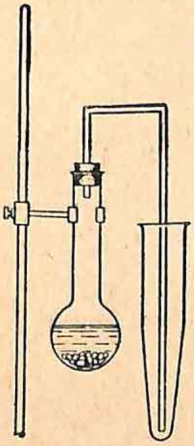

Fig. 5.29 Apparatus for preparing gas heavier than air

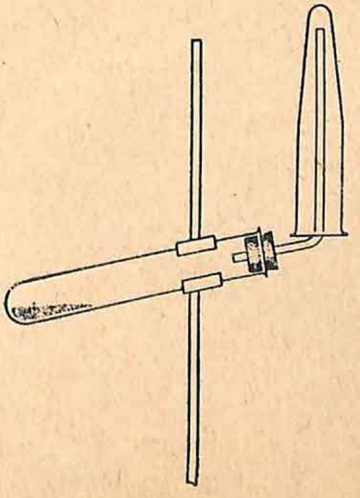

Fig. 5.30 Apparatus for preparing gas lighter than air

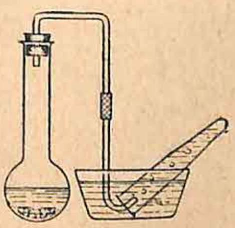

Fig. 5.31 Preparing and collecting gas under water

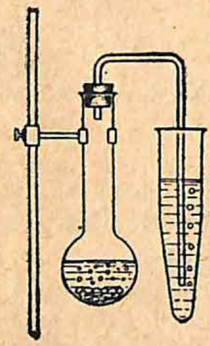

Fig. 5.32 Gas absorption by liquid.

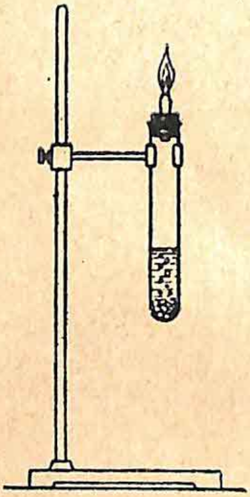

Fig. 5.33 Apparatus for combustion of gas

explosive mixture with air, it should be ignited not sooner than 5-10 seconds after the evolution of the gas has started. This time is sufficient to displace all the air from the apparatus.

Whenever necessary, gas is purified and dried by passing through bottles filled with water or solutions of suitable absorbing and dehydrating agents.

SECTION C

Science Packages for Primary and Middle Stages and Suggested Activities

Science Packages for Primary and Middle Stages

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1. Primary Stage Science Package

1. Primary science syllabi :
    - (*a*) Science in Primary school, revised syllabus classes I-V;
    - (*b*) Environmental Studies (Social Studies and General Science)—syllabus classes I and II;
    - (*c*) Environmental Studies II (General Science)—Syllabus classes III, IV and V;
2. Teachers' Hand-book of Activities for classes I-V in three volumes;
3. 'Science is Doing' textbooks for classes III, IV and V;
4. Teachers' guides to 'Science is Doing' for classes III, IV and V;
5. Primary-Science Kit and kit guide;
6. Activity learning of Science Processes—a set of slides for teacher training; with the teaching notes:
7. The films :
    - (*a*) Science is Doing
    - (*b*) Primary Science Kit
    - (*c*) Science through the Environment (Rocks and Soils).
8. Textbook-evaluation brochures for classes III, IV and V; and
9. Test items in Primary science for classes III, IV and V.

2. Middle Stage Science Package

1. Syllabi for classes VI-VIII:
    - (*a*) Science in Middle School—Revised syllabus for classes VI-VIII;
    - (*b*) Science (elements of the physical sciences and the life sciences);
2. Science textbooks for class VI —(a) Physics Part I;
    - —(b) Biology Part I;
3. -do- for class VII —(a) Physics Part II;
    - —(b) Biology Part II;
    - —(c) Chemistry Part I;
4. -do- for class VIII—(a) Physics Part III;
    - —(b) Biology Part III;
    - —(c) Chemistry Part II;

5. Teachers' Guides for Physics Parts I, II and III:
6. -do- for Biology Parts I, II and III;
7. -do- for Chemistry Parts I and II;
8. Kit Guides Physics, Parts I, II and III; Biology and Chemistry;
9. Films, film-strips and slides;
10. Textbook-evaluation brochures for classes VI, VII and VIII;
11. Test items for classes VI, VII and VIII;
12. Learning Science part I. Integrated science textbook for class VI.

3. Demonstration Science Kits for Primary and Middle stage

A list of the Kits developed so far is given below. A complete set provides the entire laboratory equipment for primary and middle schools.

1. Primary Science Kit (complete laboratory for primary schools.)
2. Physics Demonstration Kit No. I.
3. Physics Demonstration Kit No. II.
4. Biology Demonstration Kit for middle stage.
5. Chemistry Demonstration Kit for middle stage.
6. Physics Demonstration Kit No. III.

Suggested Activities

1. Experiments in Physics

SECTION I

List of activities from Physics Kits (Parts I, II, III)

S. No.	*Activities*	*Material*
1.	Elongation in the spring is proportional to the force applied.	Lab. stand, spring, meter scale, weights.
2.	Demonstration of molecular forces of attraction.	Lead cylinders, weights, Lab. stand.
3.	Improvised Magdeburg hemisphere experiment.	Rubber suckers.
4.	To show inertia of a body depends upon mass.	Trolleys, weights, thread.
5.	To prove that in the use of machines there is no gain of work.	Movable pulley, fixed pulley, spring balance, thread, stand and weights.
6.	To demonstrate that water can be made to boil at a temp. lower than 100°C.	Lab. stand, flask, water, stove, cork.
7.	To show that in rubbing charges are redistributed due to which both the bodies are electrified with unlike charges.	Electroscope, plastic strip, wool fixed on plastic strip.
8.	To assemble simple voltaic cell.	Dil. sulphuric acid, jar, copper plate, zinc plate, connecting wires, torch bulb.
9.	To assemble an electric motor and test its working.	Electric bell cum telegraph model.
10.	To assemble an electric bell and test its working.	Electric motor cum generator model.
11.	To demonstrate the phenomenon of reflection of light.	Disc holder, plane mirror, ray box.
12.	To show the propagation of light through a concave and convex mirror	Concave mirror, convex mirror, disc holder, ray box, source of light.

13.	To show that a beam of light passing through the prism gets dispersed towards the constituent colours.	Prism, disc holder, ray box, cover, screen.
14.	To show the different types of lenses.	Concave lens, convex lens, ray box.
15.	To show the focus of convex lens.	Convex lens and ray box.

Note : Special attention should be given to the use of the following items :

1. Physics demonstration kit No. 1—hollow decimetre cube (p-14), lead cylinders (p-38), device for pressure in liquids (p-62);
2. Physics demonstration kit No. 2—trolleys (p-108), clock model (p-118), Maxwell's wheel (p-137), discs with teeth and rotator for disc and metallic strip (S. No. 142, 143 and 144), thermoscope (p-165);
3. Physics demonstrations kit No. 3—smoke box (S. No. 310), disc holder (S. No. 311), periscope (S. No. 318), concave and convex mirrors (S. No. 325), electroscopes (S. N. 340), ammeter (S. No. 351), model of electric motor-cum-generator (S. No. 361), heating effect of current model (S. No. 363), model of electric fuse holder with fuse (S. No. 364 aud 365), electric bell-cum-telegraph model (S. No. 371), device for magnetic field of straight conductor (S. N. 369), device for motion of conductor in a magnetic field (S. No. 372);
4. Physics pupil's kit No. 3—simple electroscope (45), ammeter (46).

SECTION II

Activities Using UNICEF Physics Equipment

1. Matter expands on heating (Ball & ring apparatus)
2. Conductivities of different materials (Ingen Hauze experiment)
3. Series and parallel arrangement of conductor (Circuit board kit)
4. Demonstration of transformer (Dissectible transformer)
5. Generation of high potentials (Van de graaf generator)
6. Demonstration of steam engine (Steam engine model)
7. Conversion of electric energy into mechanical energy (Barlow's wheel).
8. Testing charge on electrified bodies (Electroscopes)
9. Polarisation of light (Poloride set)
10. Conversion of heat energy to mechanical energy (Crooks radioscope)
11. Specific gravity determination (Sp. Gr. bottles, universal hydrometer, Nicholson hydrometer etc.)
12. Demonstration of electromagnetic induction (Magnet and demonstration galvanometer)
13. Demonstration of action of valves in a pump (Water pump model)
14. Demonstration of cathode rays (Induction coil and cathode ray tube)

SECTION III

Physics Laboratory Techniques

1. Correct measuring of length with meter scale.
2. Correct measuring of mass using physical balance. How to correct a faulty balance.
3. Correct measuring of weight with single pan balance. How to correct if it is faulty.
4. To select proper thermometers for calorimetry experiments and to know correct use.
5. To select proper spring balances for experiments.
6. To provide proper heating arrangement (stoves or gas cylinders) and observe safety measures (fire extinguishers).
7. To know the proper use of multimeters.
8. Correction of common type of faults in resistors, bridges, potentiometers etc.
9. To provide proper electric supply in the laboratory, A.C. and D.C. distribution (LT and HT) correct wiring, capacity of wiring, fuses.
10. To maintain properly the secondary cells.
11. To maintain properly the electric instruments such as ammeter, voltmeter.
12. Drawing, interpreting, assembly and fault finding of D.C. circuit.

2. Experiments in Chemistry

SECTION I

List of activities from Chemistry Demonstration Kit

S. No.	*Activities*	*Material required*
1.	Handling of kerosene lamp.	Kerosene lamp.
2.	Determining the boiling point of a liquid.	Thermometer, lab. stand, beaker, lamp.
3.	Separation of two immiscible liquids (oil and water)	Improvised separating funnel, lab. stand, beaker, water and oil.
4.	Preparation of carbon dioxide and studying the physical properties.	Lamp, test tube, bent tube, lime water.
5.	Action of sulphuric acid on wooden splinters.	Test tube, wooden splinters, sulphuric acid.
6.	Distillation of water.	R. B. flask, lab. stand, improvised condenser, glass tubes, water, bottle.
7.	Reaction between sodium and water.	Tong, boiling tube, lab. stand, glass tube with a jet, sodium piece, water.
8.	Studying the action of an indicator on sodium hydroxide and acid.	Test tubes, litmus, phenolphthalein, water, sulphuric acid, sodium hydroxide.

9.	Interaction of acid with salt and metals (Zn, salt and sulphuric acid) using improvised kipp's apparatus.	Improvised kipp's apparatus, Zinc, sulphuric acid, salt.
10.	Showing the presence of carbon in following substances (i) wood chips (ii) saw dust (iii) sugar (iv) cotton and (v) wool.	Test tube, wood chips, saw dust, sugar, cotton, wool, lime water, lamp.

Note : Special attention should be given to the use of the following items :
Petrol gas generator (S. No. 2) and Voltameter/bell jar (S. No. 19)

SECTION II

Activities using UNICEF Chemistry Equipment

1. Electrolysis of water by water voltameter.
2. Use of centrifuge machines, hand driven and electrical driven.
3. Testing of soil by soil test kit.
4. Use of different types of glass apparatus like retort, woulf's bottle, desiccator, flat bottom flask round, bottom flask, etc.
5. Handling of blowers.
6. Fitting and use of different types of clamp and lab. stands.
7. Use of water baths.
8. Use of different types of balances.
9. Use of different types of thermometers.
10. Measurement of the volume of liquid with the help of measuring flasks, cylinders, burette, pipette etc.
11. Use of litmus papers.
12. Volumetric exercises.

SECTION III

Chemistry Laboratory Techniques

1. Heating arrangements and use of wire guage.
2. Filtration by filter papers and centrifuge machines.
3. Preparation of some gases like carbon dioxide, hydrogen sulphide.
4. Evaporation and crystallisation.
5. Condensation and preparation of distilled water.
6. Dilution of acids.
7. Weighing and preparation of standard solutions.
8. Storage of apparatus and chemicals.
9. Discussion regarding, inflammable solvent, poisonous and dangerous chemicals and their handling.
10. Handling of glass apparatus.
11. First aid in chemistry laboratory.

3. Experiments in Biology

SECTION I

List of Activities from Biology Demonstration Kit

S. No	*Activities*	*Material required*
1.	Germination of dicot and monocot seeds in root growth apparatus.	Gram and maize seeds, root growth apparatus and soil.
2.	Study of underground stems, modified for different functions.	Potato, onion, ginger, hand lens
3.	Technique of artificial pollination.	Needles, forcep, transparent paper, thread and flower buds.
4.	Simple and bud grafting	Rose plants, thread, blade, knife.
5.	Study of living protozoa.	Microscope, slide and cover slips, water containing protozoa.
6.	Study of the cells of the epithelium of mouth cavity of a man under microscope.	Knife, eosin, slide and cover slip, needles, microscope.
7.	Demonstration of absorption of water by roots.	Carrot, potato, sugar, beaker, osmometer vaseline.
8.	Transpiration by improvised potometer.	Improvised potometer, branches, red ink, vaseline.
9.	Demonstration of rise of water in soil, experiment with capillary tubes.	Capillary tubes, red ink.
10.	Demonstration of muscle fatigue	None needed
11.	Demonstration of the working of the heat	Dissecting set, dissecting tray, stand for demonstration of muscles contraction (myoscope), syringe, dropper, saline solution, nicotine or adrenalin solutions. frog.
12.	Demonstration of the mechanism of inspiration and expiration with the help of (a) rubber balloons in a bell jar (Donder's chamber) (b) freshly dissected lungs from a frog (Donder's chamber)	Donder's chamber, red ink, lungs of a dissecting frog, dissecting set, dissecting tray, cannule, thread, rubber cork
13.	Demonstration of the spinal reflexes of frog.	Boss heads, clamp with rubber cork, beakers, pieces of paper, dilute, solution sulphuric acid, frog.

Note : Special attention should be given to the use of the following items :

1. Donder's chamber (S. No. 32)
2. Stand for demonstration of muscles contraction (Myoscope) (S. No. 39)
   Auxonometer
   - (*a*) Scale-Semi circular
   - (*b*) Pointer with a block
   - (*c*) Electrodes
   - (*d*) Bone holder
   - (*e*) Weights (two rubber corks Nos. 2 and 8)
   - (*f*) Hook for tendon of muscles
   - (*g*) Hook for heart
3. Set for ergography (S. No. 42)
   - (*a*) Bracket with pulley
   - (*b*) Pencil holder with pencil
   - (*c*) Nylon string with hook and loop
   - (*d*) Platform with guide for paper
4. Root growth apparatus (S. No. 46)
5. Dissecting microscope (S. No. 51)
6. Dissecting set (S. No. 64)
   - (*a*) Scissors surgical 125 mm.
   - (*b*) Scissors fine point 110 mm.
   - (*c*) Forcep straight (pointed) 120 mm.
   - (*d*) Forceps straight (blunt) 130 mm.
   - (*e*) Dissecting scalpel 50 mm. blade
   - (*f*) Dissecting needles
   - (*g*) Blunt Probe 120 mm.

SECTION II

Activities Using UNICEF Biology Equipment

1. Use of oven.
2. Use of autoclave.
3. Use of centrifuge machines.
4. Use of balances.
5. Use of vasculum
6. Examination of permanent slides.
7. Study of different parts of ear models.
8. Study of different parts of eye model.
9. Study of different parts of heart model.

SECTION III

Biology Laboratory Techniques

1. Cleaning of slides and microscope.
2. Different parts of a microscope.
3. Preparation of 30%, 50%, 70%, 95% alcohol for staining.
4. Preparation of staining/fixatives.
    - i) safranine
    - ii) eosine
    - iii) acetocarmine
    - iv) 4% formaline
    - e) F A A
5. Temporary preparation of slides of onion peel and epidermis.
6. Care of museum specimens.
7. Collection, preservation, drying and display of insects.
8. Preparation of herbarium specimen.
9. Pithing of a frog.

SECTION D

Appendices

APPENDIX 1

Reagents, Enzymes and Indicators commonly used in a Science Laboratory

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Acetocarmine

USE: Chromosome staining. Aceto-orcein or Fuelgen give better results, but carmine is more readily obtainable.

PREPARATION: Reflux 5g (excess) carmine with 45 ml water, 55 ml glacial acetic acid. If a reflux condenser is not available, simmer the mixture in a conical flask in a fume cupboard. Filter before use.

Actetoorcein

USE: Chromosome staining.

PREPARATION: Exactly as for acetocarmine, but substituting 5 g orecin for the carmine. Propionic acid can be used in place of acetic acid, and some authorities consider the results to be better.

Aceto-alcohol fixative

USE: Precipitates chromatin, and is therefore used for fixing tissues before chromosome staining.

PREPARATION: 1 part by vol. glacial acetic acid to 3 parts ethyl alcohol (or Rectified Spirit). Material should be fixed for at least an hour, preferably longer. It will keep indefinitely in this fixative at low temperatures, and upto two weeks at temperatures above 25° C.

Alcohols

USE: In fixatives, as a preservative and for dehydration in preparing microscopic material, as a solvent for chlorophyll and in the preparation of certain reagents. Ethyl alcohol is the most generally useful. It can be bought comparatively cheaply in India as 'Rectified Spirit', approximately 95% ethyl alcohol, the remainder being methyl alcohol and water. A permit is required for its use, and is easily obtained by educational establishments. Absolute alcohol is expensive and not necessary for elementary work. As alcohol is obtainable duty free for school use on special permit, a record has to be kept of stock and amounts used, and undiluted stock has to be locked away. Excise officials have the right to inspect storage and record books.

PREPARATION: A mixture of alcohol and water undergoes a shrinkage in volume. For fixatives and preservatives, there is no need to dilute with great accuracy. A 30% alcohol solution as a general preservative is merely 30 ml alcohol plus 70 ml water (33 ml of rectified spirit in 67 ml water).

Agar

USE: As a setting agent for culture of bacteria and fungi, as it is not affected by the enzymes they produce. These are often proteolytic, therefore, gelatine is not always suitable as a setting agent.

PREPARATION: 1g agar dissolved in 100 ml/water at 70/80° C. Nutrients and salts are added as required for the culture of specific organisms, and the medium is sterilized before use at 15 lbs pressure for 20 minutes (or 7 kg for 2 minutes). At high ambient temperatures. 1.2 to 1.5g agar per 100 ml water is needed, and in high humidity petri-dishes of the medium are best stored in a desiccator if air conditioning is not available.

Benedict's reagent

USE: Qualitative and quantitative testing of reducing sugars. It is superior to Fehling's solutions as it is non-caustic, keeps well, and can be used quantitatively.

PREPARATION: Ready prepared, or:

17.3g copper sulphate crystals
17.3g sodium citrate
100g sodium carbonate

Dissolve all reagents in water and make up to 1 litre.

Buffer solutions

USE: Occasionally used in elementary work for the growth of certain bacteria. Best obtained as buffer solution tablets from the chemicals suppliers, various pH ranges being obtainable.

Canada balsam

USE: A resin solution for permanent microscope preparations. It yellows with age, and euparal is better (see below).

Calcium chloride

USE: As a dyhydrating agent, though it is not so efficient as silica gel (g. v.). Can be used for establishing humidity gradients in response experiments. A self-indicating mixture of calcium chloride (with a small amount of cobalt chloride) is best for general use.

Cobalt chloride paper

USE: Detection of water, the colour changing from blue (dry) to pink when wetted.

PREPARATION: Dip filter paper in a 5% acqueous solution of cobalt chloride, and allow to dry in a warm oven. Store in a disiccator, or in a jar with silica gel.

Culture solutions

See 'Knop's Solution' and 'Mineral Deficiency Solutions'.

Dichlorphenol indophenol

USE: Estimating Vitamin C content.

PPEPARATION: Make up a 0.1 % solution in water, and titrate against a standard solution of ascorbic acid, using a hypodermic syringe for measuring the volume. Compare with the volume of DCPIP which will just remain blue in various citrus fruit and vegetable juices.

Enzymes

Enzymes are available as solids, or as solutions. A useful proteolytic enzyme which keeps well, is pepsin in glycerine. It is obtainable from chemists. Pepsin tablets from the same source also keep well. For experimental purposes, solid enzymes are generally made up as 5% solutions.

Eosin

USE: Showing the path of water conduction in vascular plants, or as a counter-stain for animal tissues stained with haematoxylin,

PREPARATION: For showing xylem tissue, make up a 5% aqueous solution by first dissolving 5g in alcohol (about 10 ml) and adding water to 100 ml total volume. As a microscopic stain, eosin is usually prepared as a 1% solution in alcohol.

Euparal

A clear resin for mounting permanent microscope slides. It is best obtained in ready prepared form.

Fehling's solutions

USE: Testing qualitatively for reducing sugars.
Benedict's reagent is preferable.

Solution A :

69.3 g copper sulphate,
1 litre distilled water.

Solution A :

250g potassium hydroxide,
346g sodium potassium tartrate,
1 litre distilled water.
The solution should be stored in dark bottles.

Add a few drops of solution A to the substrate under test. Add solution B until there is a deep blue colour. On heating, a yellow, orange or red precipitate indicates the presence of a reducing sugar.

Fuelgen stain

USE: Chromosome staining. Best to buy in ready prepared form.

Formalin

USE: As a general preservative.

PREPARATION: Make up the strength of solution required from the 40% solution usually supplied. A 5% solution is most satisfactory.

Gelatine

USE: For bacteria—culture media, when agar is not obtainable. The proteolytic enzymes secreted by many bacteria will liquefy gelatine media.

PREPARATION: 5g per 100 ml water set at temperatures up to 25° C. Higher ambient temperatures require a larger quantity of gelatine.

Glycerol

USE: For temporary microscope preparations. Glycerol has the same refractive index as air and being hygroscopic, it does not dry out.

PREPARATION: Undiluted or as a 5% solution. The solution should have an anti-bacterial preparation added to it. If a standard preparation is not available, a very small amount of phenol can be added.

Haematoxylin

USE: Stain for animal tissues with an eosin counter stain.

PREPARATION; Best to buy in ready prepared form.

Indolacetic acid (IAA)

USE: Plant growth experiments.

PREPARATION: Can be obtained as a 1% lanolin paste, suitable for school experiments.

Iodine

USE: Forms a blue-black starch/iodine compound when added to starch. The compound is unstable to heat.

PREPARATION: An aqueous solution is used for starch testing. Iodine is insoluble in water, but is soluble in a 1% potassium iodide solution. Grind 10g iodine with 10g potassium iodide, adding distilled water while stirring. Make up the resulting solution to 1 litre. To use it, dilute the solution to a pale brown colour. Otherwise, the test colour is masked. Alcohol solutions are not suitable for starch testing, as ethanol affects the formation of the coloured starch/iodine compound.

Janus Green B (*Diazine green*)

USE: As a vital stain (non-toxic for living material) and a redox indicator. A clear blue aqueous solution turns pink under anaerobic conditions, for example in a yeast suspension. The colour change is much more rapid than the decolorisation of methylene blue.

PREPARATION: As a 1% solution, in water.

Knop's solution

USE: A culture solution for plants, either supplied to the roots or for aquatic plants, including algae.

PREPARATION: Can be bought as tablets containing the necessary substances in the correct proportions.

Magnesium sulphate 0.1g
Potassium hydrogen phosphate 0.2g
Potassium nitrate 1.0g.
Calcium nitrate 0.1g.

All are dissolved in 250 ml distilled water, adding the calcium salt last to prevent precipitation. Add 3 drops of ferric chloride as a 4% solution.

Lactophenol Blue

USE: Stain for fungi and nematodes.

PREPARATION: Best to buy in ready prepared form, together with lactophenol for washing the stained material.

Lime water

USE: Testing for carbon dioxide.

PREPARATION: Keep a Winchester of water with excess calcium hydroxide. Shake occassionally, and filter as required, topping up the Winchester with distilled water.

Mercuric chloride

USE: A 0.1% solution sprayed or painted over herbarium specimens prevents them being attacked by moulds.

This is only necessary in tropical regions. The salt is poisonous to human beings.

Mercury

USE: In manometers and for transpiration experiments. Also for making Million's reagent. Mercury is a cumulative poison, which can be absorbed through the skin and inhaled as a vapour. It should, therefore, be used and stored with care.

Methylene Blue

USE: As a vital stain and as a redox indicator.

PREPARATION: As a 1% aqueous solution. When used for staining fungi, a little detergent should be added as a wetting agent.

Methyl cellulose

USE: Slowing down protozoa for microscopic examination.

PREPARATION: As a 4% solution in water.

Miltion's reagent

USE: Testing for proteins.

PREPARATION: 1 ml mercury dissolved in 20 ml nitric acid in a fume cupboard, and then diluted by adding the mixture to 50 ml water. Extreme care must be taken not to inhale the fumes. A better method, using mercuric sulphate, is described in Nnffield Biology Teacher's Guide III, p. 68. The reagent is really best obtained in ready made form.

Neutral Red

USE: As a vital stain, especially for protozoans and rotifers.

PREPARATION: Make up a 5% aqueous solution.

Phloroglucinol

USE: Staining legnin in plant tissues, in thin sections or on the surface of larger structures, e.g. one year old twigs cut transveresely.

PREPARATION: Dissolve 5g phloroglucinol in 10 ml alchol. and make up to 250 ml with distilled water. Soak the tissue in the stain for 2-3 minutes and add concentrated hydrochloric acid. A bright red colour develops in lignified tissues.

Potassium hydroxide

USE: The absorptlon of carbon dioxide in respiration experiments.

PREPARATION: (*i*) As a 50% solution, add 50g pellets to 50 ml water, a few at a time, cooling and stirring constantly. A mechanical stirrer is advisable. There is a good deal of heat produced, and unless the mixture is stirred, the pellets stick to the glass of the container. (*ii*) Filter paper soaked in the above solution can be used in place of the liquid in apparatus of small volume e.g. in test tubes and ignition tubes when testing the rate of oxygen intake in respiration experiments.

Pyrogallol

USE: Absorption of oxygen in respiration experiments.

PREPARATION: Place 20 g resublimed pyrogallol in a 500 ml reagent bottle. Add 200 ml saturated potassium hydroxide solution (prepared as above) and quickly about 50 ml liquid paraffin. This makes an upper layer which excludes oxygen. Swirl the bottle until the pyrogallol is dissolved. Remove the solution as required with a glass pipette or large hypodermic syringe. For the preparation and storage of large quantities see Nuffield Biology Teachers' Guide III, p.p. 17-18.

Resazurin

USE: Testing the bacterial content of milk. It gives a quicker reaction than methylene blue, though this can be used if resazurin is not obtainable.

PREPARATION: Bought in tablet form. The colour changes from blue to pink to white in the presence of coliform and lactic acid bacteria. Protect the mixtures from strong light, which also affects the indicator.

Ringer solution

USE: Keeping fresh material in a solution isotonic with body fluids of the animal concerned.

PREPARATION: As tablets from most supply agencies (specify 'Mammalian Ringer').

Mammalian Ringer consists of 9g sodium chloride, 0.4g. potassium chloride 0.24g anhydrous calcium chloride and 0.2g sodium bicarbonate dissolved in 1 litre of distilled water.

Sodium dithionite

USE: To decolourise Indigo Carmine in oxygen production experiments.
PREPARATION: Make up a 1% solution, in a fume cupboard.

Sodalime

USE: Absorbs carbon dioxide when damp. It is a mixture of caustic soda and calcium hydroxide.

Starch solution

USE: As a substrate for enzyme reactions.
PREPARATION: Mix 1g starch with 10 ml water. Boil 90 ml water in a 250 ml beaker. As it is about to boil, add the starch and water mixture and stir to avoid frothing over. Boil for half a minute, and cool the solution before use.

Sudan III

USE: As a stain for fats and oils. It cannot be washed out of these substances, whereas it is readily washed out of non-fatty substances.
PREPARATION: Best bought in ready prepared form.

Silica Gel

USE: A dehydrating agent for desiccators and for establishing humidity gradients in response experiments. The self-indicating kind, mixed with cobalt chloride, is advisable. The gel can be dried out in a warm oven.

Xylol

USE: A clearing agent in microscopy. It makes tissues translucent, and is miscible with Canada Balsam and Euparal.

Litmus Is a substance of vegetable origin, soluble origin, soluble in water. An aqueous solution of litmus is violet and is known as neutral litmus. A few drops of acid added to neutral litmus will turn it red, the resulting solution being called red litmus. Accordingly, the addition of a few drops of alkali to neutral litmus results in 'blue litmus'. Litmus paper (blue or red) is prepared by impregnating strips of filter paper with solution of blue or red litmus.
PREPARATION: Litmus solution Dissolve 1 g of the solid litmus (Azolitmin) in 100 ml of water to get blue litmus solution. To the blue litmus solution already prepared add two drops of dilute hydrochloric acid in order to change its colour to red.

Phenolphthalein is a finely crystalline white powder, an organic compound of complex composition. It is used as an indicator usually in the form of a 1-2 per cent alcohol

solution. It is colourless in acid or neutral solution, and pink in alkaline.
PREPARATION: Dissolve 0 5 g of the dry reagent in 50 ml of alcohol and then 50 ml of distilled water with constant stirring. Filter if a precipitate is formed. Keep the bottle tightly corked as the solution evaporates rapidly.

Methyl orange is a finely crystalline orange powder, also an organic compound of complex composition. It serves as an indicator in the form of an orange 1 per cent acqueous solution which turns pink in acid solution and yellow in alkaline solution.
PREPARATION: Methyl orange Dissolve 0.5 g of the reagent in a litre of distilled water and filter the cold solution if a precipitate appears.

Bicarbonate Indicator (*Nuffield*)

USE: Shows the increase or decrease in carbon dioxide. It is a mixture of Thymol Blue, Cresol Red and sodium bicarbonate. The latter roughly doubles and pH shift caused by changes in CO_2 concentration.

The indicator is brought to equilibrium with atmospheric air immediately before use. The colour then appears orange-red in a test tube, and deeper red in larger quantities. As the CO_2 concentration decreases, the colour changes to purple. As the amount of CO_2 increases, the indicator becomes yellow.

The reaction depends upon the fact that CO_2 forms an acid solution in water. Strong acids cause a further colour shift at about pH 1.8, and therefore should not be used for showing colour changes. Tartaric acid, a weak acid, is suitable for demonstrating the colour changes to a class prior to use of the indicator.

The indicator can be brought to equilibrium with atmospheric air by bubbling air through the indicator in a filter flask. If Buchner filters are not available. small quantities of the indicator can be brought to equilibrium by bubbling air through by means of a dropping pipette. or in larger quantities, a hand bellows or a bicycle pump. This should be done with the same air as used in the control, that is laboratory air.

PREPARATION: 0.2g Thymol Blue.
0.1g Cresol Red

Dissolve these in 20 ml ethanol. Dissolve 0.84g Analar sodium bicarbonate in 900 ml distilled water. Mix the two solutions, and dilute 10X for laboratory use.

Indicator

Universal indicators are needed in elementary field work for estimating pH values of soil and water. Universal indicator, is available as liquid or as test papers. Narrow range indicator papers can by bought for more precise work. Generally the range encountered is from pH5 to pH8.

Indigo-carmine

USE: A useful redox indicator for testing the evolution of oxygen from submerged plants. A 5% solution is just decolourised with sodium dithionite solution. (q.v.) Oxygen in small quantities restores the blue colour.

APPENDIX 2 A

CHEMISTRY — BASIC SCIENCE EQUIPMENT

S. No. 1	*UNICEF** *Item No.* 2	*UNICEF††* *Item No.* 3	*Summary description as per UNIPAC Price list* 4	*Qty. per set* 5	*Unit* 6
1	371	251	Still water heater	1	ea
2	372	252	Saptula Laboratory 6″—150 mm	6	ea
3	424	253	Balance trip lab. 2000 gm.	1	ea
4	375	354	Borer set cork, set of 6	3	set
5	377	255	Bottle dropping, polythene 4 oz	24	ea
6	376	256	Bottle N.M. round S. Cap. Poly. 32 oz	2	ea
7	378	257	Bottle N.M. round S. Cap. Poly. 1—2 g	12	ea
8	380	258	Bottle N.M. round S. Cap. Polyprop. 16 oz	12	ea
9	381	259	Bottle N.M. round S. Cap. Polyprop. 32 oz	12	ea
10	382	260	Brush test tube, small	12	ea
11	383	261	Brush test tube, large	12	ea
12	384	262	Burette. 50 ML	12	ea
13	385	263	Burner, vaporized kerosene, vertical	2	ea
14	386	264	Clamp burette, fixed position	12	ea
15	387	265	Clamp, test tube standard	24	ea
16	388	266	Clamp tubing shut-off Mohr 2¼″	12	ea
17	456†††	267	Comprator pH wide range	1	ea
18	393	268	Dish evaporating porcelain 250 ml	24	ea
19	430	269	Dish culture petri 100 × 15 mm	24	ea
20	396	270	Funnel lab. polyprop. plain 75 mm	12	ea
21	398	271	Gauze wire with centre 6″ × 6″	24	ea
22	399	272	Jar bell 17.5 cm × 25 cm tubulated	6	ea
23	—	273	Lamp alcohol brass 5 oz (150 ml)	12	ea
24	458†††	274	Litmus indicator paper pkg. of 12	1	pkg
25	457†††	275	Litmus indicator paper red	1	doz.
26	400	276	Millboard asbestos lab. 10 × 16 × 3/16″	6	ea
27	401	277	Mortar and Pestle glass 4 oz	6	ea

1	2	3	4	5	6
28	402	278	Paper filter qualitative 10 cm	6	ea
29	403	279	Paper filter qualitative 15 cm	4	pkg.
30	405	280	Pump filter laboratory large	1	ea
31	407	281	Spatulla horn double blade 200 mm	12	ea
32	408	282	Stand support, laboratory, medium	12	ea
33	409	283	Stoppers cork XXX quality assorted	4	bag
34	410	284	Support stand large 4 ring	2	ea
35	411	285	Rack test tube, wood 12 tubes	24	ea
36	413	286	Thermometer lab-00° to 110°C	12	ea
37	414	287	Tongs crucible laboratory 9″	12	ea
38	415	288	Triangle pipestem 5 cm (2″) sides	12	ea
39	416	289	Tripod lab. iron 6″ with 2 ring	6	ea
40	418	290	Tubing latex rubber 3/16″ x 1/16″	25	ft
41	419	291	Tubing rubber $\frac{1}{4}''\times 1/8''$ wall	25	ft
42	445	292	Watch glass size 3″ (76 mm)	24	ea
43	420	293	File round 6″ second cut	6	ea
44	421	294	File triangular 5″ single cut	12	ea
45	422	295	Atomic models, set	1	set
46	423	296	Balance students twin rider	4	ea
47	425	297	Bath sand, dimeter 15 cm 6″	6	ea
48	426	298	Bath water 12.5 cm × 7.5 cm (5″ × 3″)	4	ea
49	427	299	Boat combustion 50 mm × 10 mm	2	ea
50	429	300	Crucible porcelain Cap		
51	433	301	Mercury trough Porcelain Cap 4 1b	1	ea
52	434	302	Plate cobalt glass 5 × 2.5 cm	2	doz.
53	435	303	Pump filter glass aspirator	4	ea
54	437	304	Spoon deflagrating with brass shield	24	ea
55	438	305	Stoppers cork XXX quality assortment B	2	bag
56	440	306	Thermometer lab. 0° to 360°C in 2°	6	ea
57	443	307	Weight student's balance 1 to 100 g.	4	set
58	444	308	Minerals set of 25	1	box
59	—	309	Watch glass size 4″ (102 mm)	6	ea
60	379	—	Bottle, reagent, N/M. 500 ml,	24	ea
61	373	—	Beaker, laboratory 150 ml low form	6	ea

1	2	3	4	5	6
62	377		Beaker, laboratory 250 ml low form	6	ea
63	389		Cylinder graduated laboratory 10 ml	2	ea
64	390		Cylinder graduated laboratory, polyprop. 100 ml.	12	ea
65	391		Cylinder graduated laboratory, polyprop. 500 ml.	2	ea
66	392		Dish, crystalling with spout	2	ea
67	394		Flask volumetric 250 ml.	2	ea
68	395		Flask volumetric 500 ml.	2	ea
69	397		Funnel laboratory thistle head	12	ea
70	404		Pipette, volumetric. 20 ml,	12	ea
71	406		Rods, stirring, flint, glass assorted	2	pkg
72	412		Test tube 150×16 mm without lip	72	ea
73	417		Tubing, standard flint glass, assorted	2	ea
74	431		Flask boiling 250 ml., flat bottom	10	ea
75	432		Funnel, parating, sphere 100 ml.	1	ea
76	436		Refort tubulated 250 ml.	6	ea
77	439		Test tube 150×25 mm without lip	1	doz
78	441		Tube combustion I.D. 20 mm×300mm	2	ea
79	442		Tube drying U-shaped 100×15 mm	6	ea

1* List No 022 common to (first supply of 79 sets)
(a) State Institute of Science Education
(b) State Institute of Education
(c) Teacher Training College
(d) Teacher Training Schools

2†† List No 106 common to (second supply of 500 sets)
(a) Teacher Training Schools
(b) Teacher Training Colleges

3††† Items from List N 107

APPENDIX 2 B

CHEMISTRY — BASIC SCIENCE EQUIPMENT

S. No. 1	*UNICEF* Item No.* 2	*UNICEF†† Item No.* 3	*Summary desciption as per UNIPAC Price list* 4	*Qty. per set* 5	*Unit*
80	451	331	Flexible Crystal Model	1	ea
81	452	332	Trough, Pneumatic	6	ea
82	453	333	Utility Clamp	6	ea
83	454	334	Deflagration Holder for Sodium	1	ea
84	455	335	Gas-Diffusion Apparatus	6	ea
85	458	336	Litmus Paper-Neutral	1	pkg
86	460	337	Chart of the Atoms	1	ea
87	463	338	Chart-Purification of Drinking water, Pasteur's filter, ozonisation, sterilisation, etc.	1	ea
88	464	339	Chart Manufacture of sulphuric Acid, Contact Process	1	ea
89	465	340	Chart-Fixation of Nitrogen	1	ea
90	466	341	Platinum wire 2″ length 0.3 mm dia fused in glass rod	3	ea
91	—	342	Drying cones galvanised iron 5″ high 24 ga	1	doz.
92	468	343	Udiometer tube 50 cc platinum electrodes	1	ea
93	469	344	Cork pressure, circular wheel	1	ea
94	470	345	Rubber tubing special ¼″ × 1/8″ wall	1	coil
95	471	346	Rubber tubing special 9 mm in 10 mm coil	1	coil
96	472	347	Gas jar, glass 20 × 5 cm	24	ea
97	473	348	Discs for covering above gas jars	24	ea
98	459	—	Litmus paper-blue	12	pkg
99	461	—	Gas generator	1	ea
100	462	—	Vapour Density Apparatus-150 mm Balt	1	ea
101	463	—	Chart-Purification of Drinking water	1	ea
02	467	—	Woulf's bottles 500 ml.	6	ea

1* List No. 107 common to :
(first supply of 79 sets)
(a) State Institute of Science Education
(b) State Institute of Education
(c) Teacher Training Colleges
(d) Teacher Training Schools

2†† List NSL No. 23 common to :
(second supply of 500 sets)
(a) Teacher Training Colleges
(b) Teacher Training Schools

APPENDIX 2 C

GLASS WARE FOR PHYSICS, CHEMISTRY AND BIOLOGY
BASIC SCIENCE EQUIPMENT

UNICEF Item No. 1	*Summary description as per UNIPAC price list* 2	*Qty. per set* 3	*Unit* 4
461	Beaker, Laboratory 150 ml	24	ea
462	Beaker, Laboratory 250 ml	36	ea
463	Beaker, Laboratory 600 ml	6	ea
464	Dish crystallizing without spout	2	ea
465	Funnel separating Spherical, Capacity 125 ml	3	ea
466	Gas generator, Borosilicate glass	3	ea
467	Pipette, transfer volumetric 20 ml	12	ea
468	Rods stirring with fine polished ends, borosilicate glass assorted	2	pkg
	Diameter × *Length*		
	4 mm × 125 mm		
	4 mm × 150 mm		
	5 mm × 200 mm		
	6 mm × 250 mm		
469	Tube combustion I.D. 20 mm × 300 mm long both ends open, fine polished, plain borosilicate glass	2	ea
470	Tube drying U. Shaped, plain 190 x 15 mm (height × dia.) Clear Glass (Absorption tube)	6	ea
471	Barometer Tube (Borosilicate glass)	1	ea
472	Test tube 150 × 15 mm O.D. (borosilicate glass)	288	ea
473	Test tube 150 × 25 cm O.D. without rim, (borosilicate glass)	12	doz
474	Tubing standard, borosilicate glass, assorted	4	boxes
475	Condenser, Leiping, 30 cm	2	ea
476	Friction Red Glass 1 cm dia, length	12	ea
477	Victor Mayers' Apparatus, Borosilicate glass	1	ea
478	Bottle Reagent, narrow mouth 500 ml.	48	ea

1	2	3	4
479	Cylinder, graduated laboratory 10 ml	2	ea
480	Cylinder, graduated laboratory 100 ml	6	ea
481	Cylinder, graduated laboratory 500 ml	6	ea
482	Cylinder graduated laboratory 100 ml	12	ea
483	Flask volumetric 230 ml	16	ea
484	Flask volumetric 500 ml	12	ea
485	Flask boiling 230 ml	12	ea
486	Retort, Tabulated, 250 ml	6	ea
487	Funnel, laboratory thistle head	18	ea
488	Woulf's bottles 250 cc. (2 openings)	6	ea

Note : List for Teacher Training Colleges and for Teacher Training Schools

SLU 029
Second supply of 500 sets

APPENDIX 2D

PHYSICS – BASIC SCIENCE EQUIPMENT

S. No. 1	*UNICEF* Item No.* 2	*UNICEF** Item No.* 3	*Summary Description as per UNIPEC Price List* 4	*Qty. per set* 5	*Unit* 6
1	261	151	Thermometer Clinical oral-95-110°F	1	ea
2	262	152	Syringe Hypodermic Luer 10 ml	1	ea
3	275	153	Balance trip, lab. 2000 gms	2	ea
4	263	154	Metric weights 1-1000 gms	2	set
5	264**	155	Balance Quadruple Beam	1	ea
6	265	156	Centrifuge Hand Driven 4×5 ml. Tubes	1	ea
7	349††	157	Thermo-lactometer	2	ea
8	266	158	Timer Interval 60 minutes	1	ea
9	267	159	Stopwatch 30 min.	1	ea
10	268	160	Calipers Sliding Vernier	4	ea
11	269	161	Level Carpenter, Spirit Level	1	ea
12	303	162	Micrometer 0-25 in mm grad	4	ea
14	270	163	Compass Chalkboard length 6″	1	ea
14	271	164	Protractor Chalkboard, approx, 15″	1	ea
15	272	165	Ruler Chalkboard (inches and cms).	1	ea
16	273	166	Triangle Chalkboard 24″ (set square)	1	ea
17	274	167	Drawing set geometric instruments	6	set
18	360	168	Accumulator lead acid type 2 V 60/AH	2	ea
19	276	169	Ball & Ring Apparatus	1	set
20	277	170	Ball Compound copper and iron	1	ea
21	278	171	Barometer aneroid demonstration	1	ea
22	280	172	Bell elec. 4 V battery operated	3	ea
23	281	173	Bottle Specific gravity 50 ml	6	ea
24	282	174	Calorimeter Double-walled	4	set

1	2	3	4	5	6
25	283	175	Cell Daniell	1	ea
26	284	176	Cell Leclanche E.M.F.	6	ea
27	285	177	Cell Voltaic Student's	1	ea
28	285	178	Clock Alarm approx. 65″ dial	1	ea
29	287	179	Coil induction standard type	1	ea
30	288	180	Compass Plotting 16 mm Diameter dial	12	ea
31	289	181	Compass Pocket Magnetic dia 45 mm	2	ea
32	290	182	Conductivity Apparatus, heat	1	ea
33	361†	183	Cylinders equal volume	1	set
34	362†	184	Cylinders Equal weight set of 6	1	set
35	291	185	Disc, Newton's color 18.5 cm dia	1	ea
36	292	186	Dynamo-motor Model 4-6 V.D.C.	1	ea
37	293	187	Electromagnetic induction study cutfit	1	ea
38	358†	188	Friction pad fur 20 × 20 cm.	1	ea
39	364†	189	Generator Steam Copper 1 litre	4	ea
40	294	190	Holder lens polished wood	12	ea
41	295	191	Hydrometer universal	1	ea
42	296	192	Hydrometer mason 0'-50' C in 1' C	1	ea
43	297	193	Lens-Plano-concave 50 mm F/20 cm	8	ea
44	298	194	Lens Plano-concave 50 mm F/20 cm	12	ea
45	299	195	Magnet Bar 10 cm 6% chrome steel	3	pr.
46	300	196	Magnet Cylindrical 10 cm. long	3	pr.
47	331	197	Magnet horseshoe 10 cm. long	6	ea
48	307	198	Mirror concave Spherical 5 cm. dia.	6	ea
49	305	199	Mirror Plane 15 x 15 cm glass	2	ea
50	306	200	Mirror Plane 7.5 x 2.5 cm glass	36	ea
51	307	201	Needle compass magnetic 10 cm.	6	ea
52	308	202	Organ pipe demonstration 55 cm	1	ea
53	309	203	Plate Glass 20 × 20 cm 6 mm thick	2	ea
54	310	204	Prism 2 optical glass equilateral	6	ea
55	311	205	Pulley Clamp mounted 50 mm dia	1	ea
56	312	206	Pulley single sheaf	2	ea
57	313	207	Pulley Double sheaf	2	ea
58	314	208	Pulley Triple sheaf	2	ea

1	2	3	4	5	6
59	316	209	Pump force demonstration model	1	ea
60	316	210	Pump lift demonstration model	1	ea
61	344†	211	Radiometer single vane	1	ea
62	317	212	Ray track & colour mixing apparatus	1	ea
63	318	213	Rheostat sliding contact tubular 38 cm.	4	ea
64	319	214	Rod electrical ebonite	12	ea
65	320	215	Rule wood metre	6	ea
66	321	216	Scale balance spring 500 g in 5 g	6	ea
67	347†	217	Sonometer 2-wire pattern	1	ea
68	322	218	Steam engine model	1	ea
69	354†	219	Steam trap all glass water trap	4	ea
70	323	220	Telephone set	1	set
71	324	221	Thermometer max/min Six's 8″	1	ea
72	325	222	Thermometer spirit dual 20°-120°F	1	ea
73	326	223	Tuning fork set length 10 cm (4″)	1	ea
74	327	224	Voltameter DC: 0 to 10 volts—0—35A	5	ea
75	328	225	Wire bell copper 22 S.W.G. 12 yards	2	CL
76	329	226	Wire copper DCGS.W,G. 22	1	lb
77	330	227	Wire nickel-chromium bare S.W.G. 26	1	RL
78	302	228	Magnet set of 3 with iron fitting	1	set
79	279	—	Barometer tube straight 90 cm long		

* List N104 common to:
(first supply of 76 sets)
- (a) State Institute of Science Education
- (b) State Institutes of Education
- (c) Teacher Training Colleges
- (d) Teacher Training Schools

** List N 020 common to
(second supply of 500 sets)
- (a) Teacher Training Colleges
- (b) Teacher Training Schools

*** different design of the balance

† item from List N 105

APPENDIX 2E

PHYSICS – BASIC SCIENCE EQUIPMENT

S. No. 1	*UNICEF* Item No.* 2	*UNICEF† Item No.* 3	*Description of Item* 4	*Qty.* 5	*Unit* 6
80	341	231	Nicholson's Hydrometer, suger with jar constant volume	1	ea
81	343	232	Parallelogram of Forces Apparatus	1	ea
82	345	233	Dessicator, vaccum with ground in stopcock 6″	1	ea
83	346	234	Resonance apparatus, pipe and meter scale	1	ea
84	348	235	Resistance Box, plug type 3,000 chms	1	ea
85	349	236	Plug key, electric	1	ea
86	350	237	Galvanometer, Demonstration Working-Cenco type	1	ea
87	351	238	Joule's clorimeter, electrical	1	ea
88	352	239	Barlow's wheel, magnetic brake	1	ea
89	353	240	Hare's apparatus combined U glass tube mounted on wooden polished stand with graduated meter tubes fitted	1	ea
90	355	241	Gold Leaf Electroscope	6	ea
91	356	242	Electrophorus, 4″ elec. charger/induction	4	ea
92	359	243	Plug key 2 way	4	ea
93	363	244	Overflow cylinders, plastic	6	ea
94	365	245	Glass block, rectangular size $4\frac{1}{2}\times 2\frac{1}{2}\times\frac{3}{4}''$	12	ea
95	366	246	Hook's Law Apparatus	4	ea
96	367	247	Hand, Air Pump, Vaccum and Pressure	1	ea
97	368	248	PSSC Optics Kit	1	ea
98	357	—	Friction rod-glass 1 cm. dia	1	ea

APPENDIX 2F

BIOLOGY—BASIC SCIENCE EQUIPMENT

S. No. 1	*UNICEF* Item No.* 2	*UNICEF† Item No.* 3	*Summary description as per UNICEF Price List* 4	*Qty. per* 5	*Unit* 6
1	481	351	Scale bathroom metric capacity 120 kgs	1	ea
2	482	352	Tray instar deep as 8-7/8×5×2″	1	ea
3	483	353	Tray instar shallow	1	ea
4	484	354	Thermometer clinical oral Fahrenheit	6	ea
5	485	355	Clamp shutt-off tubing Hoffman	5	ea
6	486	356	Stone oil arkansas 6″×2″×½″	1	ea
7	487	357	Chart vision snellen alaphillit	1	ea
8	488	358	Tape measuring steel 6 ft. (2 Mtr.)	1	ea
9	489	359	Forceps dressing 6″ (15 cm)	12	ea
10	—	360	Scalpel belly blade 1-½″	12	ea
11	491	361	Scissors guaze 8½″	2	ea
12	520	362	Balance trip lab 2000 gm	1	ea
13	492	363	Metric weights 1-1000 gms.	1	set
14	495	364	Borer set cork set of 6	1	set
15	496	365	Bottle dropping T.K. 60 ml.	36	ea
16	497	366	Brush 'Camel's Hair' fiat 1″	6	ea
17	498	367	Cover glass microscope slide 22″ x 22 mm	4	box
18	500	368	Funnel lab. polyprop plain 75 mm	12	ea
19	501	369	Funnel lab. polyprop plain 100 mm	12	ea
20	412†	370	Jar bell 17.5 cm×25 cm tubulated	3	ea
21	503	371	Lamp alcohol brass 5 oz (160 ml)	6	ea
22	507	372	Slide microscope plain 75×25 mm	6	box
23	508	373	Support funnel 4 slotted holes	3	ea
24	509	374	Support stand large 4 ring	1	ea
25	510	375	Racktest tube wood 12 tubes	12	ea
26	512	376	Thermometer—00° to + 110° C	4	ea

1	2	3	4	5	6
27	514	377	Watch glass 3″ (76 mm)	12	ea
28	515	378	Pins dressmaker plated ¼ lbs.	2	box
29	516	379	Hole garden shank type 7×4-¾″	2	ea
30	517	380	Rake garden 12 curved teeth	2	ea
31	518	381	Spade garden square point	2	ea
32	519	382	Trowel garden 5½×3¼″	6	ea
33	521	383	Bottle aspirator polyethylene 500 ml	1	ea
34	522	384	Bottle reag N/M Amber 250 ml	6	ea
35	523	385	Cork sheet compressed 30×15 cm×6 mm	36	ea
36	524	386	Desicator vaccum scheibler	1	ea
37	525	387	Dissecting set	1	set
38	504	388	Magnifier pocket lens type	12	ea
39	526	389	Magnifying glass reading style 3″	10	ea
40	527	390	Needle dissecting s/s in handle	3	doz
41	528	391	Pan dissecting wax lined	12	ea
42	529	392	Pins entomological white ½ oz.	1	pkt
43	530	393	Plate glass 30×30 cm 6 mm thick	2	ea
44	531	394	Plate glass 75×75 3 mm thick	1	doz
45	—	395	Slide microculture one concavity	1	doz
46	532	396	Strop razor wooden handle	1	ea
47	533	397	Vasculum	2	ea
48	534	398	Jar glass (preserving jar) 1 pint	24	ea
49	535	399	Jar glass (preserving jar) ½ pint	24	ea
50	—		Beaker laboratory 250 ml. lon form	3	ea
51	—		Beaker laboratory 600 ml. low form	3	ea
52	—		Cylinder graduated laboratory 100 ml.	6	ea
53	—		Funnel laboratory thistle head	6	ea
54	—		Students dissecting microscope	3	ea
55	—		Microscope monocular	1	ea
56	—		Microscope students	4	ea

1	2	3	4	5	6
57	...		Test tube 150×6 mm without lip	36	ea
58	...		Tubing standard flint glass assorted	2	box

* List N 105 common to (first supply of 79 sets)	(a) State Institute of Science Education (b) State Institute of Education (c) Teacher Training Colleges (d) Teacher Training Schools
† List SLN 021 common to (second supply of 500 sets)	(a) Teacher Training Colleges (b) Teacher Training Schools
* List No. 108 common to (first supply of 79 sets)	(a) State Institute of Science Education (b) State Institute of Education (c) Teacher Training Colleges (d) Teacher Training Schools
* List SLV 024 common to (Second supply of 500 sets)	(a) Teacher Training Colleges (b) Teacher Training Schools
†† from List SLV 025	

APPENDIX 2G

BIOLOGY — BASIC SCIENCE EQUIPMENT

S. No. 1	UNICEF* Item No. 2	UNICEF†† Item No. 3	Summary description as per UNIPAC Price List 4	Qty. per set 5	Unit 6
1	542	411	Enamel Mug with handle	1	ea
2	544	412	Bell jar with knob and ground rim	3	ea
3	545	413	Chart, Biology, set of 60 with tripod	1	set
4	546	415	Charts, Physiology & Hygiene, set of 12 Tripod	1	set
5	547	415	Insect collecting net	1	ea
6	548	416	Plant Press	1	ea
7	549	417	Soil Test Kit	1	ea
8	550	418	Finger Bowl Dish	2	ea
9	551	419	Section Razor for freehand sections	1	ea
10	552	420	Biology Microslides 1 Mount Smear 2 Diatoms 3 Molds 4 Onion Root tip 5 Bone, Human 6 Skin, Human 7 Kidney, Human 8 Human Blood 9 Amoba Proteins 10 Trichina Worm 11 Hydra 12 Earthworm	1	set
11	553	421	Botany and Zoology Microslides		set

* List No. 109 common to (first supply of 79 sets)
(a) State Institute of Science Education
(b) State Institute of Education
(c) Teacher Training Colleges
(d) Teacher Training Schools

†† List NSLV 025 common to (for second supply of 500 sets)
(a) Teacher Training Colleges
(b) Teacher Training Schools

APPENDIX III

Further Reading

A. TEXTBOOKS/WORKBOOKS FOR CLASSES I TO VIII (NCERT Publications)

1 Science is Doing for Class III
2 Science is Doing for Class IV
3 Science is Doing for Class V
4 Biology Part I for Class VI
5 Biology Part II for Class VII
6 Biology Part III for Class VIII
7 Chemistry Part I for Class VII
8 Chemistry Part II for Class VIII
9 Physics Part I for Class VI
10 Physics Part II for Class VII
11 Physics Part III for Class VIII
12 The Curriculum Guide on Nutrition, Health Education and Environmental Sanitation in Primary Schools.
13 Learning Science, Integrated Science Textbook for Class VI, Part One.
14 Environmental Studies, Teachers Guide for Classes I and II.
15 Improvising Science Teaching Kits for Schools
16 Teaching Science by Using Local Resources
17 Biology demonstration kit, instructional manual
18 Physics demonstration kits, parts I, II, III, instructional manuals
19 Chemistry demonstration kits, instructional manuals
20 Kit Guide to science is doing.

B. SUPPLEMENTARY READING (NCERT Publications)

1 The Life of Insects
2 ABC of the Atom
3 Space Flights
4 Medical Plants
5 Rocks Unfold the Past
6 Our Agriculture
7 About Flying
8 Bird and the Bird Watching
9 Units on Electricity

C. SUPPLIED BY UNICEF TO TEACHER TRAINING SCHOOLS

1 Teaching Elementary Science
A source book for elementary science by Joseph, Victor, Hone, New York.
2 Readings in Science Education for the Elementary School
by E. Victor and M. Lerner, New York.
3 Elementary Science Teaching Activities by Sunde, New York.
4 Improved Teaching Through Experimentation by Emmer, New Jersey.

5 Handbook of Audio Aids and Techniques for Teaching Elementary School Subjects by A.B. Gudwin, New Jersey.

6 Apparatus—source book of information and ideas (1967) by Nuffield J London.

7 The book of experiments, book I (Eng. version) by Leonard de Vries, tr[illegible] by Eric G. Breeze, London.

8 The book of experiments, book II (Eng. verson) by Leonard de Vries, translated by Eric G. Breeze, London.

9 The book of experiments, book III (Eng. version) by Leonard de Vries, translated by Eric G. Breeze, London.

10 Elementary Teachers class room Science Demonstrations and Activities by David E. Hennessy, New Delhi.

11 General Science for Primary Schools—
Teachers handbook of activities 1 thru 3 volumes, NCERT, New Delhi.
Volume I Volume II Volume III

12 General Science for you Volume I, New Delhi.

D. UNFSCO PUBLICATIONS

1 New UNESCO source book for science teaching, 1973
2 The study of environment in school
3 The organisation of museums, 1960
4 The organisation of the small public library, 1963
5 School furniture development: an evaluation, 1975
6 Small technical libraries, 1973

E. OTHER BOOKS

1 The book of experiments by
Leonard de Vries, John Murray, London, 1967

2 Science Model Making, by
Robert R. Hopwood, John Murray; 1968

3 The design of biology (chemistry and physics) laboratories for Asian second level schools,
Asian Regional Institute for School Building Research, Colombo, Ceylon, 19 68

4 Handbook of laboratory distillation by
Krell, Erich, Amsterdam, Elsevier Publishing Co., 1963

5 Laboratory distillation practice by
Coulson, E.A. and Herington, E.F.G., London, George Newnes, 1958

6 Chemistry and Biology laboratories by
Schramm, Werner, Oxford, Pergamon Press, 1960

7 Laboratory Experiments in Chemistry by
Metcalfe, Clark H. and others, New York, Holt, Rinehart and Winston, 1966

8 Laboratory instruments, their design and application by
Elliot, A and Dickson, J. Home., London, Champan and Hall, 1959

9 School laboratory management by
Sutcliffe, Arthur, London, John Murray, 1950